AIEE PROCEEDINGS
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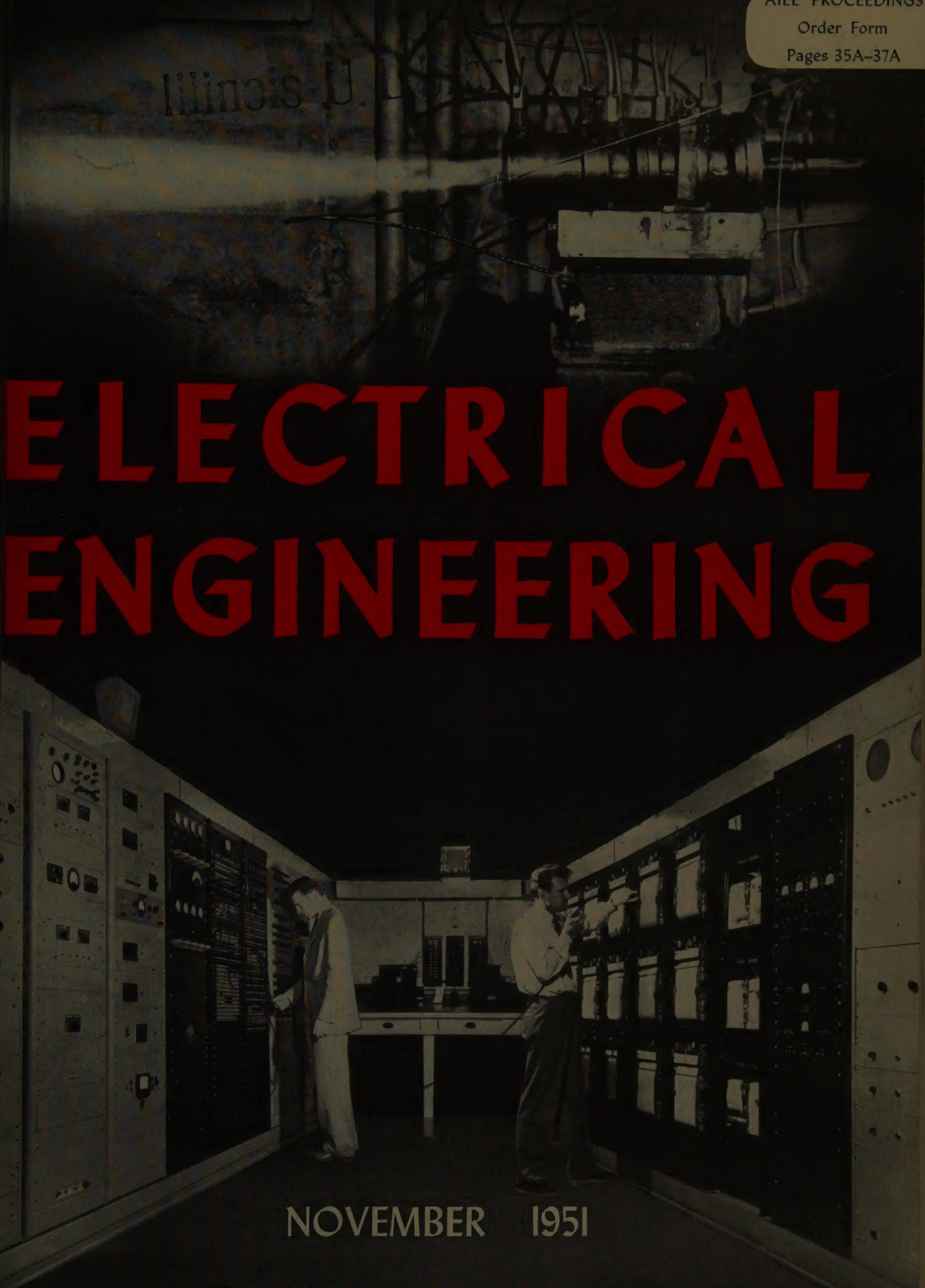
Pages 35A–37A

ELECTRICAL ENGINEERING



NOVEMBER 1951

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ELECTRICAL ENGINEERING

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The Cover: The jet engine shown in the upper part is undergoing test at California Institute of Technology's Jet Propulsion Laboratory. The equipment pictured in the lower part is a central recording station which serves a number of remote test cells. See "A Central Data-Recording System for a Jet-Propulsion Laboratory" on pages 957–60 of this issue.

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HIGHLIGHTS........

Engineering Manpower Convocation. Keyed to the theme of "Engineering—Its Future," these four speeches look at the problem of the critical shortage of engineers from the standpoint of the schools, the Armed Services, industry, and various governmental agencies and committees (*pages 947–55*).

A Central Data-Recording System. To make the most efficient use of testing and recording equipment, the Jet Propulsion Laboratory at the California Institute of Technology has installed a centralized data-recording system which serves a number of test sites. While particularly suitable for testing jets and rockets, this type of installation would serve well for other kinds of testing (*pages 957–60*).

Electron-Tube Heat-Transfer Data. Tube designers will find in Mrs. Buckland's article a number of charts and graphs useful for evaluating the heat dissipating characteristics of vacuum tubes with various types of cooling systems. Evaluation of thermal resistance is the principal topic (*pages 962–66*).

Industrial Plant Power Sources. Should an industrial plant generate its own electric power or buy it from a utility? Many industrial processes have special features which make it economical for the plant to generate its own power. These features, and the types of generating equipment which take advantage of them, are discussed (*pages 969–73*).

An Unattended Microwave Repeater. The circuits of the unattended repeater stations of the new transcontinental microwave relay system are the subject of this third article of a series describing features of that system. Particularly stressed are the new developments which were required to give the system sufficient linearity (*pages 976–81*).

New Single-Phase 4-Motor Equipments. This new design for rapid-transit cars features a truck-mounted motor driving each axle and appreciable savings in maintenance costs. The equipment operates on 11,000 volts and has a cam-operated controller for resistance acceleration (*pages 981–82*).

Transformation of Block Diagram Networks. Block diagram networks provide a labor-saving technique for the study of closed-loop control systems. A number of theorems are presented for transforming and reducing such networks to single-loop systems for more convenient analysis by the use of single-loop servomechanism theory (*pages 985–90*).

A Magnetic Tape Oscillograph. A special magnetic pickup head has been designed so that the advantages of magnetic tape recording can be applied to the recording of the transient phenomena of power systems. The head will produce an output voltage proportional to the magnetomotive force exerted on it by the tape with polarity dependent on polarity of the magnetomotive force. The output is independent of the tape speed (*pages 993–97*).

Earth Inductor Compass. A coil rotating in the earth's magnetic field will develop an induced voltage which can be amplified and used to trigger a strobotron circuit. Light from the strobotron will "stop" a pointer which rotates simultaneously with the coil. This device offers promise as a suitable compass for light planes and other small craft (*pages 1001–03*).

Vibracode Supervisory Control. Narrow-band frequency modulation is used in the Georgia Power Company's carrier current system. The equipment uses audio-frequency tones to provide the control, supervision, telemetering, and alarm signals. Known as the Vibracode system, this method makes use of driven tuning forks as tone sources and resonant reed relays as the tone responsive elements (*pages 1004–08*).

Precipitation of High-Resistivity Dust. Contrary to what might be expected, high-resistivity dust can cause much trouble in electrostatic precipitators as a result of the high-voltage drop which develops across the layer of collected dust. This article is a discussion of such troubles as they occur in low-voltage 2-stage precipitators of the type used in air conditioners (*pages 1009–13*).

Internally Cooled Generator Coils. The development of internal cooling with high-pressure hydrogen gas opens up a new era in the design and construction of turbine generators (*pages 1013–15*).

AIEE Proceedings. The latest AIEE *Proceedings* order form appears in the advertising section of this issue (*pages 35A–37A*). This form lists technical program papers presented at the AIEE Pacific General Meeting held in Portland, Oreg., August 20–23, 1951, and the AIEE Fall General Meeting held in Cleveland, Ohio, October 22–26, 1951. A list of order forms for *Proceedings* sections now being honored appears elsewhere on this page.

News Index

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions*.

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Associates, Members, and Fellows only.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Nov '50, p 44A	Middle Eastern District Fall General (1950)
Mar '51, p 35A	Winter General
Jul '51, p 23A	Southern District North Eastern District Great Lakes District Summer General
Nov '51, p 37A	Pacific General Fall General

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 36, N. Y.

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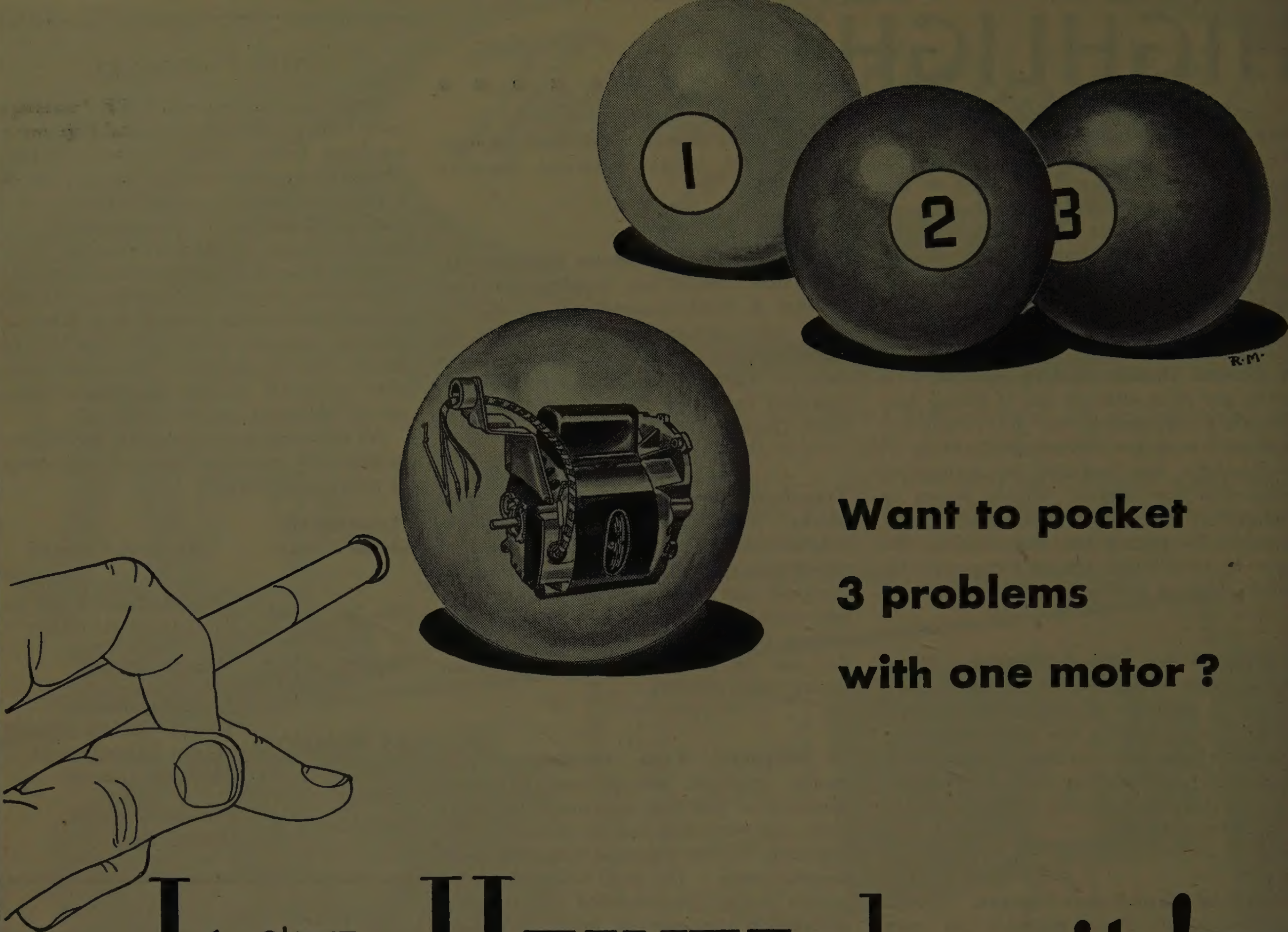

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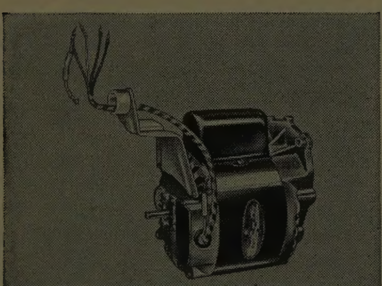

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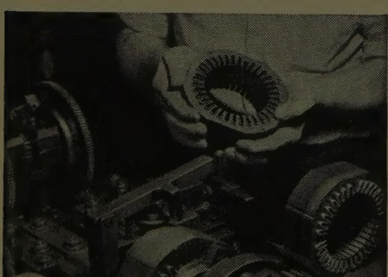

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Engineering Manpower Convocation

The purpose of the Convocation was to inform the engineering profession of the country about the critical shortage of engineers and the program of the Engineering Manpower Commission and to invoke widespread co-operation in carrying it out.

Reflected Light Is Not Enough

A. C. MONTEITH
FELLOW AIEE

THIS MEETING has been called to discuss a problem of vital importance to the entire nation. It is a problem whose gravity is appreciated within the profession but not sufficiently understood by some branches of our Government and particularly by the general public. In short, it is the problem of whether our technical resources, which are the foundation of our country's growth, are to be maintained strong for the future welfare of the people—or whether they are to be sapped away through wasteful and indiscriminate use.

The solution to this problem is one which we engineers and scientists must ourselves initiate. The very fact that the problem exists today is an indication that somewhere along the line we have failed to educate society concerning the place of the engineer in the economic life of the country. It is true that the engineer's works are recognized as being eminently successful, many as being near-miracles, but there is lack of appreciation of what is required to create an engineer and his technical working facilities.

ROLE OF ENGINEER IN SOCIETY

TO SET THE STAGE for the discussion which is to follow, let me trace for you the role of the engineer in society. This may help us determine what it should be in the future—in fact, must be if we are to avoid weakening our industrial economy and our ability to defend ourselves against aggression. Let me make clear at the outset that we are talking about all branches of science and engineering.

Let us look outside the room for a moment—and I mean momentarily; otherwise, there would be too much to review. The transportation wonders such as the railroad, the automobile, and the airplane; the bridges, office buildings, steel plants—all are engineering accomplishments, and there is still much that can and must be done if we are to maintain the standard of living to which this country has become accustomed. So it goes. While the examples to illustrate our points will be chosen at random, and while some might feel we overemphasize one phase of the many branches of technology, it must be emphasized again that we have the whole broad field of science and engineering technology in mind.

If one were to trace the growing importance of the engineer and scientist, where would one begin? Perhaps with that forgotten, unrecorded day when the wheel was conceived, for that marked the beginning of labor-saving devices. But for our purposes of evaluating engineering, it is convenient to begin with the turn of the present century. By then the industrial age was well under way. In fact, most people believed technology had reached its zenith and they generally looked for little further development. The engineer had, by and large, done his job.

We smile now at such a state of affairs. The general populace could not foresee what lay just ahead. We now know that only a small beginning in technical accomplishment had been made.

The Model-T Ford, because it was mass-produced, introduced the automobile age in 1908 when it brought the motorcar within reach of an average American. About 1900 Marconi, Fleming, and deForest brought the miracle of radio, and in 1920 Conrad introduced radio broadcasting by which music, news, and entertainment were brought into the home by the turn of a switch. The foundation laid by Edison and Westinghouse before the turn of the century developed electricity into an everyday necessity for even the humblest of homes. The application of the steam turbine to electric generators by George Westinghouse in 1899 resulted in cheap electricity. This brief recital of what the scientist and engineer have done in the last 50 years could go on indefinitely. The few points cited give support to the statement that more progress has been made in technological achievements in the past 50 years than in the previous 5,000 years.

None of this could be foreseen by the typical American of 1900. But before chiding him too much for his complacency, his unawareness, let us remember that it was not just a condition peculiar to a half-century ago. It is a perpetual condition. It exists now.

We must not censure the public for accepting without question the accomplishments of the scientist and engineer. Nor can we expect the average person to have the imagination to want or to see what the technical man has not yet accomplished. At any given time, technical developments seem to be in a generally satisfactory, indeed, a wonderful, state. Nobody felt the lack of automobiles before they were introduced. No one longed for radio broadcasting before 1920. The public apparently does not understand that to maintain and to advance our standard of living, more engineers, more scientifically trained men must be available.

Figures 1 and 2 show the striking increase in the utiliza-

These four articles were presented at the Engineering Manpower Convocation held in Pittsburgh, Pa., September 28, 1951. The Convocation was under the auspices of the Engineering Manpower Commission of the Engineers Joint Council, with the co-operation of the Engineers Society of Western Pennsylvania and the Guidance Committee of the Engineers' Council for Professional Development.

The articles by Mr. Monteith, Mr. Trytten, and Mr. Brown are condensations of the original text; Dean Hollister's article is presented in full.

A. C. Monteith is Vice-President, Westinghouse Electric Company, Pittsburgh, Pa.

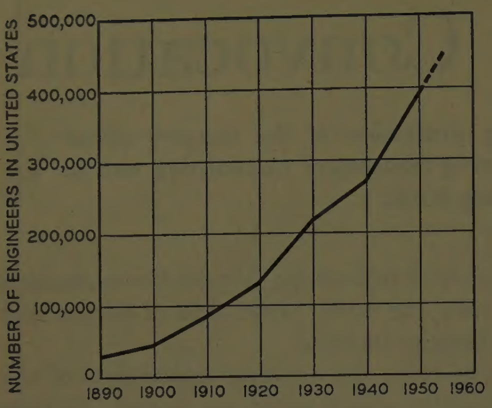
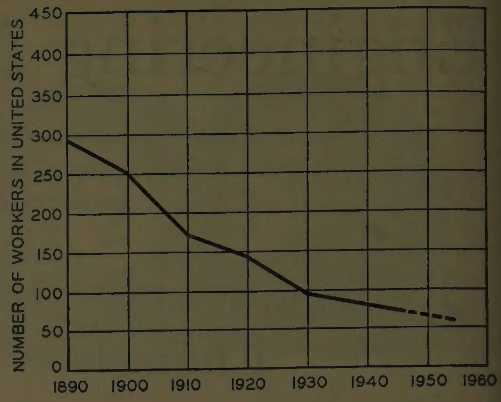


Figure 1 (left). Growth of the engineering profession

Figure 2 (right). Number of workers per engineer

Figure 1 indicates a growth of 800 per cent in the ranks of the engineering profession in the first half of the 20th Century. Of even greater importance is the sharp decrease in the number of workers per engineer that is shown in Figure 2



tion of engineers in the United States over the past 60 years. Together, these illustrations constitute dramatic proof of the tremendous increase in the importance of engineering in our economy.

Table I presents an interesting analysis of the utilization of engineering personnel in the United States broken down with respect to occupational status. Five of the principal branches of engineering are included. Of particular note is the high percentage (from 30.0 per cent to 47.5 per cent) of engineers enjoying administrative and management status. It is expected that these percentages will continue to increase as both the products and processes of industry become more technological in nature and an engineering training becomes a requisite for more key positions.

Table I. Utilization of Engineers in United States—1946

Occupational Status	Civil, Per Cent	Mechanical, Per Cent	Electrical, Per Cent	Chemical, Per Cent	Mining and Metallurgical, Per Cent
Administration and Management	47.5	34.3	31.9	30.0	42.4
Consulting	8.4	5.7	5.7	3.3	7.1
Design, Development, and Research	29.6	39.0	38.3	44.4	28.0
Manufacturing, Production, Operating	7.6	10.2	12.2	14.6	15.1
Sales Engineering	1.2	5.7	6.3	3.0	2.3
Other	5.7	5.1	5.6	4.7	5.1
Total	100	100	100	100	100

The number and complexity of problems is building up in any given activity so that the number of engineers must continue to increase if we are to expect a continuing improvement in our standard of living. I see no reason why we should at this time view ourselves more optimistically than Sir Isaac Newton viewed himself in the early 18th Century when he said, "I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the seashore, diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, while the great ocean of truth lay all undiscovered before me." The 200 years since Newton's time is to the total space of time as a second is to our lifetime, so we have no reason to view ourselves in any different perspective.

Consider energy, for example. Our use of energy is rising rapidly per capita, and the population is increasing at a fast rate. We have repeatedly told ourselves that we have centuries of coal reserves, mountains of shale oil, billions of barrels of oil still to be found; and now we hear that atomic energy may make all other energy forms obsolete. But if we take a close look, we find the energy picture is not so bright. For example, our liquid-fuel reserves are probably adequate for another generation or two, perhaps enough for our sons but not enough for our grandsons. Our way of life is now absolutely dependent on liquid fuel. We see no immediate way to get along without it. This demands that we learn how to produce it from coals, lignites, shales, tar sands, and perhaps even from growing things, in anticipation of the day when the output of oil wells dwindles to a mere trickle relative to our needs. Eventually, we will have to assign whole schools of scientists and engineers to learn how to live on our energy income from the sun, instead of on the energy so conveniently stored for us in the ages past. Taking it any way you like, there is an enormous amount of work yet to be done, so we must persistently drive ahead.

WAR AND THE ENGINEER

So far in this discussion I have not recognized the Biblical statement that "there shall be wars and rumors of wars." Wars have always been a part of our life in this world, and in the mid-point of the 20th Century we have not found the solution for preventing wars. The best preventive for war is finally being recognized as a strong defense. We are fast moving into an era where the possibility of war must be recognized as a part of our existence. As a matter of fact, it is probable that for a time our way of life will revolve around the prospects of war. I have credited engineers with much of the advance of our standard of living, but I must also admit that the engineer has been responsible for making wars more vicious as time has passed. The very strength of our productive capacity is also a basic reason for more vicious war. Much thought has been given to evolving more diabolical methods of waging war. We must recognize with increasing alertness that this demands the best thinking of our engineers if we are to survive as a nation. The engineer must be given his opportunity to continue to devise weapons and not to take too much time out himself to put them into action. His other engineering accomplishments, such as the radio, the automobile, and the like, are operated by people without technical training, and the engineer is free to put his effort into their improvement. So it must be with defense weapons.

Unfortunately, the policy of maintaining an adequate eservoir of technically skilled youth has met resistance. t is a part of our philosophy of democracy that people are qual—with equal rights and with equal responsibilities vhen we are in danger. There is an inherent feeling that omehow it is not right to say that certain young men must carry arms while others are reserved for technical education nd technical jobs. Thus we have heard the accusation hat a "caste" system would be set up by making young nen capable of professional education deferred from immediate military draft. This feeling can come only from the emotions, not from the mind or from wise consideration of realities. Our potential enemies would like nothing better than for us to follow this natural, but emotional, urge. They know that American technology is the chief barrier to world domination. Now our people—the American people—must be made to fully understand this. Dissipation of our technical resources is the worst possible disservice we can render to our armed forces.

Our whole case so far has been for civilian use of engineers. Let it at this point be understood, once and for all, that I do recognize the ever-growing necessity for technology in the armed forces. Engineers are necessary to keep our technical war machine working at greatest efficiency. The officers' training now conducted in a number of engineering schools has placed many outstanding men in the military reserves, and the whole process of universal military training and service could ultimately place every able-bodied man in reserve status. My purpose in making such a positive case for industry is to present the other side of the picture: to emphasize the necessity that we secure a proper balance between the requirements of the armed forces and essential industry inherent for the survival of our country, at least during the next few years when it is evident that engineers will be in short supply. It will take much study and sober judgment to secure an equitable balance.

What I have said has been spoken and written many times before—but that is just the point. We in this room understand the contributions of science and engineering. The general public seems to accept them. This same public now expects continuing technical improvement without, I believe, understanding what is one of the basic foundations, that is, strong technical planning and development plus the opportunity in a free economy to pit ingenuity and skill against all comers. I cannot, on a long-range basis, visualize how scientific thinking could blossom to the fullest degree in anything but a free competitive atmosphere. We must be sure that the importance of this basic ingredient is understood by the public and that every encouragement is given to young enterprising people who want to study for scientific and engineering careers. We have been deficient in selling this to the public; hence, the great decline in professional enrollment in colleges.

Our economy, our way of life, could perish of thirst if we permit a further drought of technical manpower. This is not generally understood and we simply are not getting our story across. America, its ideals, its productivity and resultant standard of living, its very continuance, is a function of engineering and scientific leadership. Without superiority in technology we can be victims of superior numbers. Presentation of a program for action is the reason for this Convocation. It is up to every engineer and his Society to shoulder the responsibility for its success.

Engineers: A Vital Resource in Critically Short Supply

S. C. HOLLISTER

THE AMERICAN PEOPLE recognize that their country has a tremendous capacity to produce goods of all kinds. They have seen this country turn out prodigious quantities as materiel for support of its Army, Navy, and Air Force and for the support of its allies in defending the world against the destruction of democracy. The people have great faith in the country's power to produce. This power hinges upon the scientific and technical know-how through which the abilities to design, research, produce, and properly operate the vast wheels of industry, come about. The country witnessed a great development of its scientists and engineers during World War II. It came to realize that great dependence was placed upon the achievements of these men in the final winning of the war.

Now we face perhaps the most critical emergency of our history. We face this with a great shortage of engineers—a shortage which is destined to grow worse rather than better over the next half dozen years at least. It is for the purpose of explaining the nature of this shortage that I appear here today.

Figure 1 shows the number of graduates from our engineering colleges for each year since 1940. It will be noted that in 1940 about 11,000 graduates were turned out. In the war years, the operation of Selective Service had the effect of taking all able-bodied men out of our engineering schools, so that during those years we were not educating engineers at the normal rate. Ours was the only major belligerent country on either side of the conflict of World War II to follow this policy. Men who should have been graduated in those years are badly needed in the present emergency, but we do not have them.

As the figure shows, the return of veterans from World War II, through the operation of the so-called G. I. Bill, greatly increased the number of engineers graduated from the schools up to and including this past June. The number of graduates from the engineering schools that we may expect in the future years up to and including 1960 is indicated. This number can be quite closely estimated because the men who will graduate between now and 1956 have either entered or have applied for admission in the engineering colleges of the country. Engineering educators for several years past have been quite concerned at the drop in freshman enrollment. The percentage of high-school students now entering the engineering colleges is about 20 per cent below what it was during the prewar

S. C. Hollister is Dean, Cornell University, Ithaca, N. Y.

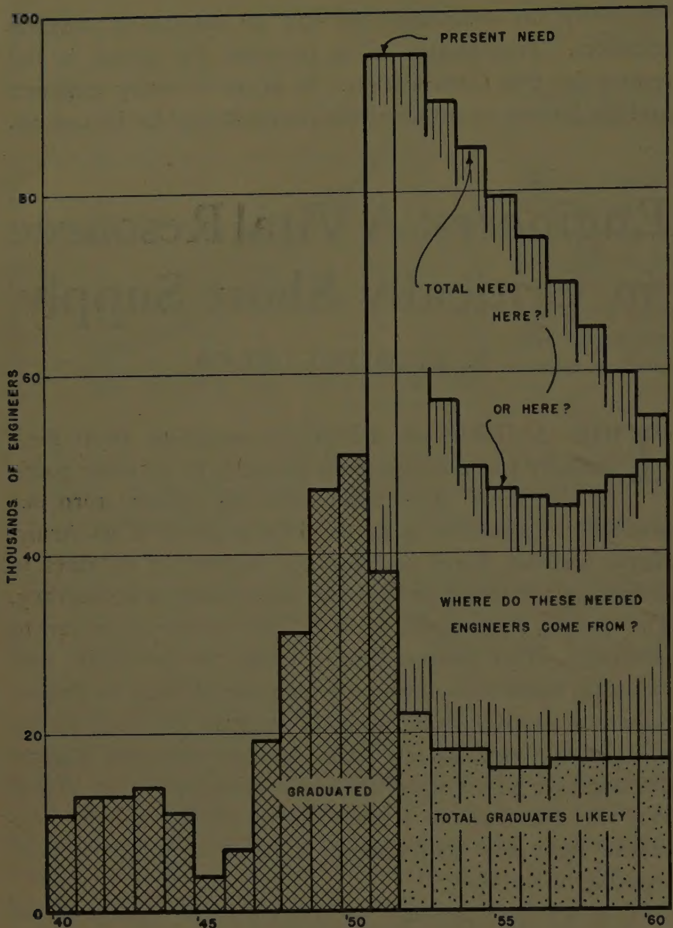


Figure 1. The critical shortage of engineers

years. It is not likely that there will be any substantial increase over the estimate of the total number of engineering graduates for the next decade because the high schools are not expecting to increase the numbers graduating by any large amount until the end of that period.

It should be noted here that the numbers expected to graduate from the engineering schools, as shown in Figure 1, result from the total anticipated enrollment without allowance for the effect of any withdrawals due to the draft or due to the operation of armed force reserves. If withdrawals are made from college population, then the numbers graduating will be reduced by such amount.

A survey of industrial and governmental need for *civilian* engineers indicated that 80,000 were needed by June 1 last. Add to this an estimated 15,000 to be used by the services in uniform and the total is 95,000 as shown in the figure. The class of 38,000 was all that was available to meet this year's need. Half of these are or soon will be committed to the armed forces. How will the remaining need be met?

Next year's need is not likely to be less than last year's. Thereafter it *may* reduce, dependent upon policies that may be established by the government and by industry. If aggressive action is taken by both in concentrating the engineering talent at the points where it will do the most good, a major reduction in need may be effected, as indicated in Figure 1.

At best it will not be possible to meet the need from the supply of graduates now expected from the colleges, because this supply will be less than half enough. Before the war, nearly 6 per cent of the boys graduating from high school entered engineering colleges. Now the rate has dropped to 4.8 per cent. About 10 per cent would be needed to meet peacetime civilian needs alone.

The needs stated herein are in terms of the customary pattern of utilization of engineering graduates. Since the percentage of boys beginning engineering education is far below what is indicated as the need, and is declining, the pattern of utilization of engineers must be greatly modified, if present necessary engineering work is to be accomplished with the limited number available.

Industry should take the following steps promptly:

1. Use engineers *only* in jobs in which engineers are required.
2. Do not hold young engineers in "intern" positions longer than necessary to qualify them.
3. Move engineers to positions of maximum responsibility compatible with ability and experience.
4. Release engineers from positions not requiring engineering training.

The following steps should be taken at once by the military services in the national interest:

1. Engineering specialists in critical engineering positions in the defense effort should not be called to duty regardless of reserve status.
2. Engineers should be assigned only to duties involving capacity use of their technical training and experience either through the draft, or through the reserves.
3. Reservists in enlisted ratings whose subsequent training qualifies them as engineers should not be called and used as enlisted personnel, but should be used only in assignments which must be filled *only* by an engineer.
4. Reserve officers whose subsequent training qualifies them as engineers should, if recalled, be assigned *only* to duty which requires engineering training.

Government Agencies and Policies

M. H. TRYTTEN

IT SHOULD BE CLEAR from what has already been said today that the major problems confronting the nation are in the field of manpower or are closely related to manpower. It is also true that in the manpower field the problem is most acute and has its greatest impact for the age groups coinciding with the age of college attendance. This makes the present manpower crisis extraordinarily important for the future because the actions which are taken to solve these problems will have their major effects not so much now as in the future—5 and 10 and 20 or more years from now. It is not too much to

M. H. Trytten is with National Research Council, Washington, D. C.

state that an unwise resolution of these problems could fundamentally alter the nature of our civilization and dissipate its essential strength to the point where it will be extremely vulnerable in any future conflict.

The most important characteristic of the present situation is that there are no precedents for most of its features. 1951 is so different from any other year of decision that little help can be found by scrutinizing the past. We have had experience with the problems of both peace and war. But this is neither war nor peace but an uneasy and fluctuating admixture of both, and we are determined to maintain and preserve our civilization and to assume a posture of defense. We shall have both guns and butter. We shall do all of this with controls on our manpower confined to a very small proportion of our youth, the males of little more than a half-dozen years apart in age at the maximum. And withal the motivation of national crisis is largely lacking. This small group of young men must furnish the armed force manpower supply and our supply of trained personnel in all categories, for the present and the future. This is much more of an era of training and preparation for conflict than a period of warfare. Therefore, for the present the mobilization of both manpower and production should be considered primarily a preparatory and training effort. The fact that some portion of those in Service must see actual combat as severe as in any previous war complicates both planning for training and combat.

There need never be any deprecation of the heroic quality of American military personnel nor of its leadership during the last two wars; nevertheless the real secret of American success was due to the extraordinary number of highly trained people in the various sciences and engineering. Had the supply of engineers and scientists on our side been less, most surely the speed and effectiveness of our technology must have been less. The result would have been less powerful equipment and at a later date, to be paid for by much greater casualties, loss of strategic objectives, greater costs in men, time, and equipment, and eventually greater losses to the world in disintegration, destruction, and disorder.

MAINTAINING THE SERVICES AT 3,500,000

These facts have not been adequately considered in the manpower planning which has taken place up to the present time. That this is true can be seen from an analysis of the present situation with regard to the maintenance of the armed establishment at its target level of 3,500,000. The summer of 1951 has seen an apparent lull in the manpower demands of the Services. This is due to the extraordinary rapidity with which the Services were augmented from a manpower total of less than 1,500,000 men at the outbreak of the Korean incident, to the present total of somewhere in the neighborhood of 3,500,000. This rapid build-up, however, was due to certain extraordinary methods and operations. These included:

1. The extension of enlistment contracts which occurred immediately after June of 1950, so that those already in the Services were arbitrarily given one year of added service.
2. The involuntary recall of reservists and organized reserve units.
3. The wave of voluntary enlistments in large measure precipitated by popular reaction to the draft situation during the winter.
4. The induction of about 6,000 through Selective Service.

These extraordinary methods will not be available indefinitely. Reservists are now by law eligible to apply for discharge after 17 months' service. Organized units can be retained for more than 24 months. The present appropriation bill for the Armed Services contains another limitation for certain types of reserve personnel for only 12 months of service. The effect of all these facts is that the reserve strength available at this time will be used up rapidly or become unavailable. Similarly, the extension of enlistment contracts can occur only once under the present law. Also the pool of persons available for military service who have not previously seen service and who are between the ages of $18^1/_2$ and 26 is becoming depleted very rapidly. It is estimated now that less than a million men over $18^1/_2$ are available for induction or enlistment.

With a rapid turnover which seems certain for the Armed Services for the next 21 months, it seems possible to predict at this time that in something considerably less than two years the manpower available for military induction above the age of $18^1/_2$ will disappear. From then on the strength of the Armed Services will need to be maintained through the influx solely of the supply of manpower coming of military age, that is, at that time young men passing the age limit of $18^1/_2$ will be the sole supply of manpower from which to maintain the Services at the level of 3,500,000.

Table I is a simple calculation of the number of persons necessary on a rotational basis and needed annually if the Services are to be maintained at the best target level, and under the assumption of a given length of service which is indicated in the table. It is here assumed that the length of service is the same for all. It will be noted that the import of this table is that to maintain from this supply of oncoming youth a military establishment of 3,500,000 men will require over four years of service from each if no exemptions are promised for anyone.

Table I. Annual Increment Needed to Maintain the Strength of the Active Armed Forces at 3,500,000 Men

Average Period of Service	Annual Requirement	Per Cent of Whole Age Group Reaching Maturity	Per Cent of Those Who Qualify from Each Age Group
2 years	1,750,000	145.8	202
3 years	1,166,000	97.1	135
4 years	875,000	73.0	101
5 years	700,000	58.3	81
6 years	583,000	48.6	67

This table is based on 1,200,000 males coming of military age annually. In actuality the number for the current year is less than that by one-eighth (1,050,000). But the number is used as a reasonable expected average for the present decade. 72 per cent may be expected to be ac-

ceptable for training (864,000) and this number yields the percentages in the fourth column.

Table II is more realistic, and more representative of the probable situation. It is based on the fact that the length of service is not the same for all members of the group. Some persons are "careerists," remaining in the establishment for the better part of their active careers; others stay in military service not for a whole career but for periods of several years and above a single enlistment. Defining as "careerists" all persons who remain in military service more than one enlistment period, it can be estimated that the number of such persons in military service at the present time is probably about 750,000. It is also estimated that their average length of service is approximately 10 years. With these estimations, one may then reduce the number of persons to be provided by inductions through Selective Service, or 1-term enlistments reduce to 2,750,000. However, it is to be noted that to maintain 750,000 "careerists" in the Service for an average length of 10 years will require a minimum of 75,000 per year and possibly a somewhat greater number in view of the effects of attrition. The number of persons coming of military age is for the present approximately 1,050,000. Of these not over 72 per cent can qualify mentally or physically for military service. This will provide an annual flow into the pool of available manpower of about 864,000; subtracting 74,000 to supply the careerists leaves a supply in the pool annually of about 790,000. This, therefore, is the number which must maintain the military establishment of 2,750,000 on a rotational basis. Table II presents the calculation of the relationship of the average length of service and the supply of personnel. It will be noted from this table that for this situation which will probably be very close to reality sometime between the summer of 1952 and the summer of 1953 it will be necessary to require $3^1/_2$ years of service of each one reaching $18^1/_2$ years of age if we are to maintain a military establishment of 3,500,000 men.

Table II. Annual Increment Needed, in Addition to Those Choosing the Services as a Career, to Maintain the Strength of the Active Armed Forces at 3,500,000 Men

Average Period of Service	Annual Requirement	Per Cent of Whole Age Group Reaching Maturity	Per Cent of Those Who Qualify from Each Age Group
2 years	1,375,000	122	174
3 years	917,000	81.5	116
4 years	687,500	61	87
5 years	550,000	48	69
6 years	487,000	43	61

It is the close scrutiny of these figures which led the Institute of Manpower Utilization and Government Personnel to declare in August of this year:

"Assuming that military requirements necessitate the maintenance of an armed establishment of 3,500,000 men, it is our opinion that this cannot be accomplished within the present statutory requirements and administrative policies. Moreover, it is essential that present statutes and policies be further amended to insure that an adequate proportion of the number coming of age each year be selected for training in the sciences, professions, and skilled crafts so as to be available for specialized service where most needed in the military forces or in civilian employment after their training is terminated."

IMPLICATIONS OF SITUATION

The implications of a situation which can give rise to this arresting statement are many and most significant. It is clear in the first place that regardless of what changes in statutory requirements in Federal policies may arise as a result of re-evaluations of the situation, there will inevitably be a sharp competition for the same limited manpower pool by the needs of the military establishment, the needs of the nation for flow of trained personnel, and other needs usually closely related to the national security both now and in the future. Obviously, some re-evaluation must occur and no doubt will take place when the extent of the manpower stringency is sufficiently realized. Such a re-evaluation may result in sharp questioning by the Congress of the target totals of manpower for the military establishment. It does not appear likely, however, that a substantial change in this number will occur. Unquestionably, the length of service will again come under scrutiny with a possibility of an extension of the present statutory limit of 24 months to a longer period. It seems most likely, however, that the Congress will not extend this by statutory alteration but will give to the President the authority to extend it by Executive Order if necessary. Again it seems likely that increased consideration will be given to the removal of exemptions for persons over 19 for reasons of prior service or limited disability. Unquestionably there will be a greater effort to utilize marginally qualified personnel, and additional consideration to the appropriate uses of woman-power no doubt will be given. But the larger implication in this whole situation is that the needs of the nation for specialized personnel of both the professional college and university trained grade and the subprofessional or skilled craft category will be inadequately provided for as a result of the effort. While a requirement that persons so selected for specialized training shall spend some minimum time in training may be desirable for its effects on public reaction, it can have nothing but an adverse effect on the military manpower problem because it would require military training facilities for these persons and the corresponding staff to provide the necessary personnel required by the high technological level of our civilization and present military methods; it can only result in a serious deficiency in our eventual ability to meet the challenges the future is certain to hold.

PERSONNEL DEMANDS

An examination of the engineering situation discloses a remarkable increase in the demands for personnel not only because of the needs of remobilization, but also because of the sharply increasing demands of the civilian economy aside from the military requirements. Dean Hollister has given figures which show beyond any doubt how critical the shortage of engineers is.

The situation in the sciences is roughly comparable.

While available statistics are not as satisfactory for accurate prediction, discernable trends are very similar. The nontechnical demand for scientists at the present time is approximately the same percentage-wise as that of engineers, indicating an unfilled demand for scientists at the present time which must be of the order of from 20,000 to 30,000. Unlike engineering, however, it is clear that the demand is greater the more extended the preparation and training of the category. The shortage of scientists is most acute at the level of research directors, project directors, group leaders, and independent research personnel. Parallel to the situation in engineering is the fact that the graduation of scientists in the coming years also will decrease progressively.

FEDERAL POLICY

The situation is one warranting grave concern. The major outline of this story seems incontrovertable. The demand for military manpower is certain to be so great as to construct a substantial interference with training in science and technology. To meet situations of this kind, extraordinary effort will be called for in the direction of national policy and Federal procedure. So far organizations in the Federal Government have been exceedingly slow to recognize that manpower will probably be the most critical problem in the nation. Up to now, the most important manpower decisions in the Government have been made by indirection. The establishment of military manpower shows the adoption of production goals in many areas. The allocation of scrap materials, and every other large square design made by an agency of the Federal Government, necessarily created specific manpower demands for allocations. One cannot establish a production goal in one commodity without creating immediately the necessity for a certain fixed number of manhours in each of the wide category of specializations. Heretofore, there has been wholly inadequate attention given to whether such supplies of personnel exist, or whether the demands upon them have been adequately phrased so as to avoid rapidly fluctuating demands for such people and to give others exceedingly vital information relating to the manpower supply.

Recently there has been established a National Manpower Policy Committee and an advisory committee on specialized personnel in the Office of Defense Mobilization. These instrumentalities make possible an approach to these problems but whether these mechanizations are adequate or not can only be determined in the course of time. The independent organizations of such specialized personnel as are represented by the group meeting here today can play an unusually important role. If the problem is to be satisfactorily met, there must be a flow of information, a flow of informative opinion, and a mechanization for assistance—all of them relating to the grass-roots level. It is my firm conviction that the satisfactory solution to this plan is more likely if the many engineering and scientific societies throughout the nation are wholly alert to it and appropriately organized to assist in arranging the appropriate solutions and at implementing decisions which may have to be made.

A Program for the Engineering Profession

CAREY H. BROWN

Beyond the necessity for technological preparedness in the military sense, the engineering profession is faced with the challenge of increasing the productivity of industry and improving the material standard of living. Either in itself constitutes a ringing challenge, but when the two are superimposed the necessity for aggressive attack upon the problem becomes even greater. In this period of our history it is not merely essential that technology develop and produce the weapons and equipment essential to the maintenance of military superiority, but that, at the same time, it carry out its major share in the development and production of articles of such attractiveness, usefulness, and serviceability to the civilian economy that the cost of military preparedness can be borne. The wreck of our civil economy would be as disastrous as military defeat. Maintenance of strength in our civil structure as well as in our military establishment is essential. In both, the role of the engineer is a dominant one, supply of engineering manpower is a critical problem, the failure to make full utilization of available engineering skills is a wasteful procedure which must be eliminated.

THE SUPPLY OF ENGINEERS

Dean Hollister has fully disclosed the inadequacy of engineering manpower to meet the needs both present and in the near future. The multiplicity of advertisements for technical-personnel-wanted attests to the present need; the figures of engineering enrollment in the colleges attest to the need of the near future. This emphasizes the necessity for effort at the local level to convince more young men—and perhaps young women as well—of the wisdom of entering engineering colleges.

There are perhaps two main factors influencing the decision of the high-school graduate. The first is the essentiality and importance of engineering as a profession, and the second is the fitness of the student, both as to natural aptitude and inclination and as to educational preparation, to undertake the rigors of a course of engineering study. Such conditions as employment, salary, and recognition are also factors.

The statement that high-school preparation is deteriorating, so far as preparation for entry into engineering colleges is concerned, has been made from time to time. It is no doubt true in certain quarters, less accurate in others, and not at all true in still others. Two reasons have been advanced for such change in the high-school output. These are, respectively, the loss of male teachers of science and mathematics during the war and the increasing attention to instruction in the so-called humanities, either as a result of such losses or because such increased attention was of itself considered desirable. To the extent that

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engineering or pre-engineering students are now being adversely affected by policies permitting the draft of their instructors or their call as reservists, these policies should come under careful scrutiny.

Attack by the Engineering Manpower Commission (EMC) upon this phase of the problem sprang from the first startling announcement of the facts by Dean Hollister in December, 1950. This attack has been made along three main lines. First of all, effort was made to secure correction of the charts and data exhibited over the past few years in college registration quarters and elsewhere indicating that engineers were in oversupply; these data have been changed to more truly depict the present situation. EMC also sent out to principals and guidance and science teachers in 23,000 high schools throughout the country data on the same subject in an effort to secure increased engineering enrollments. The third step taken was EMC's survey of engineering needs made in May-June of this year (EE, Sept '51, pages 843–44). This survey indicated needs far greater than those previously forecast and has consequently served to emphasize the need for drastic action in the conservation, utilization, and training of engineering manpower.

THE UTILIZATION OF ENGINEERS

Previous remarks have related to the existing and prospective shortage of engineers and scientists to meet the country's needs. The second great segment of the problem confronting us is proper utilization of the engineers available. For purposes of a review as to what has been done and the suggestion of a program for the profession this may be considered under three headings.

Engineers in private employment: A major portion of engineers are engaged in industry. The needs of various industries for engineers vary in accordance with the nature of the industry itself and to some extent—where engineering design or practice is not, strictly speaking, required—with the predilection of the individual employer as to the type of personnel and training which gives him most effective results. The nature of the activities of engineers engaged in sales, purchasing, and the like varies so much from place to place that it is impracticable to make any sound generalization with regard to the justification for the use of engineers in such positions during an emergency such as now faces us. Two factors enter the situation. The first is that engineers who have been so employed for any considerable length of time probably now lack knowledge of the skills and techniques essential in the fields of design, development, and mechanical or chemical production, where our greatest needs exist. The second factor is that engineers who are nonessential in their present positions, whatever they may be, will probably be drained off into more essential engineering activities as the demand for their services makes itself felt.

It is the engineer properly engaged as such in private industry, along with his counterpart in the Armed Services, who is the critical figure in the present shortage. The young engineer is in many cases equally, sometimes even more, in demand than his more experienced confrere, for much of the technology now critically important is so new that only recent students have any training whatever in its application. A belief that the technical requirements of industry can be met by men generally over military age, even if there were enough of them, is therefore a fallacy.

As a means of assuring prompt integration into industry of newly employed engineers, with consequently more effective advancement and utilization of their skills, EMC has urged upon industry the establishment of high-level training courses comparable to the hospital internships of the medical profession. Certainly, within industry itself, every effort must be made through training, reassignment, up-grading, and the like to meet the present requirements. Steps of this nature can be made effective only by local action in individual industries. The pressure of scarcity probably will automatically lead to such measures in time, but preferably they should be initiated early to avoid the loss of production which otherwise will occur.

Engineers in Government: With regard to engineers employed as civilians in governmental agencies, national, state, and local, certain steps have been taken upon initiation by the United States Department of Labor. The United States Civil Service Commission issued instructions to all Federal agencies regarding the development of a program for maximum utilization of engineering personnel with the Federal Government and a program is under way to explore the possibilities of utilization of the engineering personnel of state, county, and municipal governments on a full-time or part-time loan basis to the Federal defense agencies and to other vital defense activities. This program, if it becomes effective, should be particularly helpful in the field of civil engineering.

The United States Office of Education has developed plans for a reactivation of the Engineering, Science, Management War Training (ESMWT) program followed during World War II for intensive, short-term courses in colleges and universities. This National Defense Training Program is designed to prepare persons for specific employment in defense production establishments. The engineering schools and colleges have been requested by the Office of Education to co-operate in making available the services and facilities of these institutions, including permission for part-time employment of engineering students and faculty members, to assist key defense industries urgently in need of such assistance.

Engineers in the Armed Services: The problem of the engineer and the Armed Services is an extremely difficult one. The proposed legislation which later led to enactment of the 1951 Selective Service Act at one time contained a provision for the exemption each year of 75,000 young men to enter technical and scientific training. This would include engineers, doctors, physicists, chemists, and so forth. The figure of 75,000 was a rough estimate of annual requirements arrived at without any real statistical attempt at accuracy. While this provision was pending, the President issued a Selective Service memorandum providing for the deferment of an indefinite number of college students conditioned upon class standing and record in a special examination to be given to applicants for such deferment. This created such a furore, based upon emo-

onal rather than practical grounds, that Congress elimi-ated the proposed provision to permit 75,000 enrollment ach year in scientific courses without interference by the raft, and the Selective Service memo was modified to rovide that results of the deferment examinations pre-iously referred to should be considered by local draft oards as one factor in reaching a decision in individual ases. Furthermore Congress, before passing the Act, nd apparently because of the public outcry against xemption or indefinite deferment of any group, added provision to the effect that deferment for any cause nakes an individual subject to the draft until he reaches he age of 37. The justice of adding perhaps 10 or 15 ears to the period of draft liability of a student deferred, ay, for one year to complete his course, is questionable. ut as the provision written into law applies to all de-erments, including those for dependency, it cannot be onsidered on the basis of any one group. It is to be oted that in spite of this provision for extended liability o the draft, many students applied for and took the exami-ations as a basis for application for deferment.

The effect of Selective Service upon engineers—or rospective engineers—may be considered from the tandpoint of two groups other than students. As to the eferment of engineers in defense industry, provisions for onsideration of their cases have been set up in the various ervices, but the variation between services and the arbi-rary action in many cases have been such as to cause onsiderable difficulty. No sound procedure has yet een evolved for proper determination of the value to the nateriel aspect of the Armed Forces of an engineer in efense industry as compared to the value of the same man n uniform, where he might or might not be utilizing his ngineer training.

The later possibility—namely, that he might not be tilizing his engineering training—has seemed all too revalent. The Commission has received notice of so nany cases of this nature as to evidence a deplorable lack f policy for assuring that engineering and scientific skills mong draftees are recognized as a basis for routing their ossessors to assignments where such skills will be utilized.

The reservist problem has some of the same aspects, nd some of its own. The Armed Services must be given redit for preserving records of the qualifications of their eservists, but the difficulty lies in the fact that in calling reservist the services think of the qualifications of the ndividual as of six or more years ago. During that period nany a young man, through the G. I. Bill or otherwise, as acquired a technical education and possibly practical xperience as well; yet he might be assigned to his former vork anyway.

Another difficulty lies in the wide gap—administra-ively—which separates civilian employees from uniformed ersonnel. This exists within the Defense Department tself where, for example, the Engineer Board at Fort elvoir was combing the colleges for young civilian engi-eers while some 20 recent graduates were among a group f draftees who had just arrived. The detail of draftees vho are sent to other agencies, such as the Atomic Energy Commission, is surrounded with still greater difficulties.

A proper over-all handling of the situation requires the development of an entirely new administrative routine with regard to individuals of special qualifications.

Maintenance of superiority in weapons and in production is so critical to this nation that continued apparent indifference of the Defense Department to this situation is unthinkable. One of the several efforts to find the means of securing more consideration of the utilization of engineers was met with a reply essentially to the effect that the Armed Services would take what men they wanted and industry would get along with those who were left. The recent appointment under the Chairmanship of Dr. Flemming of a Committee on Specialized Personnel promises a means of bringing more forcibly to the attention of the Defense Department the necessity of assigning technically trained men to technical jobs where their training is fully utilized. Otherwise our superiority in weapons will be lost.

A PROGRAM FOR THE PROFESSION

EMC, AS NOW constituted, is sponsored by the Engineers Joint Council (EJC). The Commission consists of three members of each of the five national engineering societies composing EJC, supplemented by three members from the American Society for Engineering Education—as is most appropriate in view of the student problem involved. Following similar objectives, a group from the American Chemical Society has just initiated "A Proposed Educational Program to Acquaint the American Public of the Role of the Scientist and Engineer and the Impact of Science and Technology on Modern Living."

The technology of our country is at a critical point. If we are to be the Arsenal of Democracy we must outdesign and outproduce our enemies. Our very survival depends on so doing. And to maintain military superiority we must continually keep ahead in technical achievement. Aside from the military aspect, there is much reason to believe that while heretofore we have considered ourselves as living in the technological age, we have actually only been approaching that age. Recent advances in science have been so rapid that the engineer is challenged as never before. It is our function to translate these advances into means for the survival of our civilization and for an ever-improved standard of living. The engineer's role, his opportunities and responsibilities, are destined to become greater and greater as science continues its advance.

To play his part, each individual, particularly in this emergency, must so devote himself to his own task that the total engineering output shall not suffer by his deficiency. As individuals and as members of local engineering organizations we must encourage increasing numbers of able young men to enter the profession.

The engineer must become articulate as to his work. Most of all he must continue to observe the high standards of professional ethics which dignify the profession. He must contribute his share of public service in the manner to which he is best fitted. His example should inspire young men of the land to follow in his footsteps in further advancement of the engineer's responsibility for direction of the forces of nature into the field of man's service.

Protection of Electric Equipment Against Corrosion

H. E. SPRINGER
MEMBER AIEE

CORROSION OF VITAL PARTS of electric equipment presents a serious problem in many industries which manufacture or use chemicals, or in which corrosive gases, dusts, or liquids are a by-product of the process operations. It is also present in plants located near salt water, in mines, and even in steam-generating plants which use hogged fuel or coal. Corrosion of electric apparatus not only causes high maintenance and operating costs but presents a definite safety hazard.

As demands for reliability of performance become more exacting in present-day manufacturing processes, the necessity for adequate protection of electric equipment against corrosion is receiving increased recognition from operating and design engineers, both in laying out new installations and in modernizing existing ones.

Acids, alkalies, salts and brines, high temperature, moisture, and abrasive dusts are inseparable from many industries. They are also in varying degrees corrosive to many of the materials used in the manufacture of electric equipment, such as copper, steel, cast iron, lead, silver, tin, aluminum, cadmium, chromium, and insulating materials.

Examples of some of the extreme cases of such effects are illustrated in Figures 1 and 2.

Normally in clean atmosphere no special precautions are required to protect electric apparatus. However, in industries where corrosive agents are present, it is very necessary to provide suitable protection for the equipment to insure reliable performance.

In general, there are two ways to accomplish this: 1. to remove the equipment from the corrosive atmosphere; or 2. to provide equipment designed to operate in it.

The first alternate requires selecting locations for the equipment which are away from the corrosive conditions, or else suitably enclosing and air-conditioning it. The second requires a careful study of the corrosive conditions involved and careful selection of materials and apparatus which will resist them.

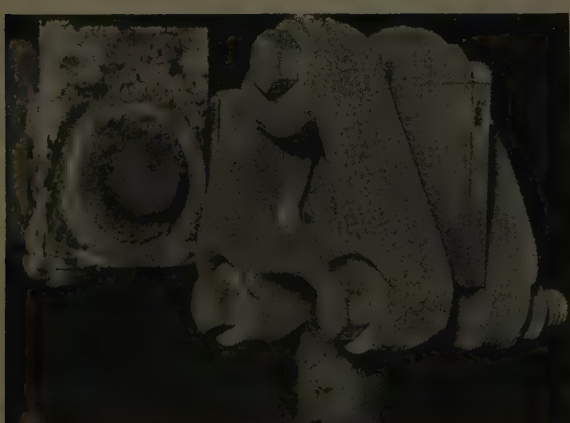

Figure 1. 2,300-volt bus gutter showing corrosion of steel, aluminum, and copper from exposure to traces of chlorine gas and moisture

Usually high-voltage power apparatus must be located outdoors. When it is necessary to locate such equipment near salt water, or where there may be other corrosive effects, it is well to use overrated bushings and insulator strings to provide extra creepage distance. It is also advisable to clean insulators frequently and to keep the total number of insulator positions to a minimum.

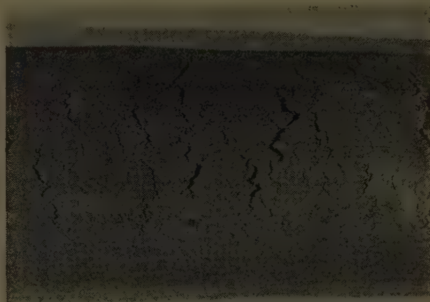

Figure 2. Lead cable sheath crystallized possibly from stress or vibration and exposure to air

All metal surfaces should be kept well painted, including bolts, line hardware, and bus work. Transformers and switchgear are available with "subway" finishes which provide extra protection in corrosive places.

Load center transformers, switchgear, motor control cubicles, motor-generator sets, lighting distribution apparatus, and other equipment of this type is best protected by enclosure in air-conditioned vaults, either inside or outside of other buildings.

Drive motors and small control apparatus more often must be located where conditions are not favorable. It is therefore necessary to select apparatus of construction which will resist corrosion and to protect it as well as possible by proper and frequent painting.

The totally enclosed fan-cooled motor and the dust- and water-tight National Electrical Manufacturers Association class III and IV control equipment provide the best protection for this class of service in general.

In motor sizes above 500 horsepower the totally enclosed fan-cooled construction is relatively expensive, and it is often more economical to use force-ventilated or heat-exchanger construction in order to exclude undesirable atmosphere.

The use of good wiring materials and construction in corrosive atmospheres is equally as important as protecting other apparatus and should not be overlooked.

Digest of paper 51-301, "Protection of Electrical Equipment Against Corrosion i Industrial Plants," recommended by the AIEE Committee on General Industry Applica tions and approved by the AIEE Technical Program Committee for presentation at th AIEE Pacific General Meeting, Portland, Oreg., August 20–23, 1951. Scheduled fo publication in AIEE *Transactions*, volume 70, 1951.

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A Central Data-Recording System for a Jet-Propulsion Laboratory

C. G. HYLKEMA R. F. STOTT H. S. SEIFERT

Recording experimental data from a number of widely dispersed test stations is achieved efficiently in this laboratory by centralizing the recording equipment in a single location. The recording center contains all recording, intermediate, and control equipment which can be combined into any desired system by means of patch cords.

IN JET-PROPULSION research, equipment is often operated at high emperatures and pressures. artly because of the hazard volved and partly because of e high noise output, these perations often are carried ut behind concrete barri-ades and at widely separated ocations. The Jet Propulsion Laboratory of the California nstitute of Technology has a number of widely dispersed oncrete test cells. To equip each test cell or experimental etup with a complete set of electric instrumentation was onsidered too expensive; consequently the plan was dopted of having each test location share in the use of a rge central pool of instruments.

In the recording system set up at this laboratory, a group f recorders in one central location is used for recording uantities being measured in widely scattered test locations. ince this system records only electrical quantities, trans-ucers must be used for converting pressures, temperatures, nd so forth, into voltages. These voltages are transmitted ver a system of telephone cables.

The central recording system comprises the transducers, est-cell equipment, the cable network, amplifiers, re-orders, control gear, and a number of special devices uch as timers and remote indicators. Although the ecording system was designed to meet the specific needs f rocket-motor development at this laboratory, it is pplicable, with appropriate modifications, to other aboratories and research programs.

JET-PROPULSION INSTRUMENTATION

ET-PROPULSION experiments usually are concerned with the reaction forces produced by the flow of heated uids. Consequently the physical quantities—time, tem-erature, pressure, mass flow rate, and mechanical force—ust be measured over rather wide ranges. The duration f a typical experiment is short; for example, a rocket otor may operate for only 1 to 2 minutes and in some cases or only a few seconds. As a result, accurate timing of vents, such as the opening and closing of valves, is re-uired, and instruments with high-frequency response are ecessary. The transient values of pressures and tempera-ures are often as important as the steady-state values. All of these considerations make necessary a wide variety of transducers and recorders which in some situations must be operated by special time-sequence circuits since events occur too rapidly for human operators to participate.

A typical laboratory or rocket-motor test requires a large number of instruments for a short time interval; after the test there may be no demand for these instruments for a long time while changes are being made in the experimental equipment. When need arises again for instruments, it may well be for an array different from those previously used. Thus it becomes prohibitively expensive to install permanent and adequate instrumentation at each test station. Such duplication may be avoided by using a mobile instrument system mounted in a suitable vehicle or a centrally located collection of instruments, permanently installed and capable of being connected to any test site. The latter is more satisfactory because it saves the time of transporting, connecting, and disconnecting a mobile unit; it makes possible the maintenance of the instruments under optimum conditions where they can be calibrated frequently in a clean and temperature-controlled environment, away from the dirty and often corrosive atmosphere of the test cell; and the instruments are protected from the jolting due to frequent transportation. Considerable manpower saving results; one engineer and two technicians can operate the recording center. Uniform circuit conventions and terminal jack fields facilitate maintenance and permit flexibility and ready interchangeability of instruments. A systematic calibration procedure tends to eliminate errors which might occur if operational responsibility were shared among a large number of persons. Expensive specialized equipment is available to research programs whose secondary importance would not justify the purchase of this equipment for their exclusive use.

So many tests made at this laboratory are carried out at locations remote from a central recording network terminus that a mobile recording system, mounted in a small truck, has been found necessary, in addition to the stationary instrument center.

Much jet-propulsion testing was and still is done with mechanical instruments. It has been necessary to supplement these instruments with electric transducers to make a centralized system possible. Although the relative accuracies and other merits of mechanical versus electrical

he work described in this paper was carried out at the Jet Propulsion Laboratory at e California Institute of Technology, Pasadena, Calif., under a contract sponsored by e Department of the Army, Ordnance Corps.

. G. Hylkema, R. F. Stott, and H. S. Seifert are all with the Jet Propulsion Laboratory, alifornia Institute of Technology, Pasadena, Calif.

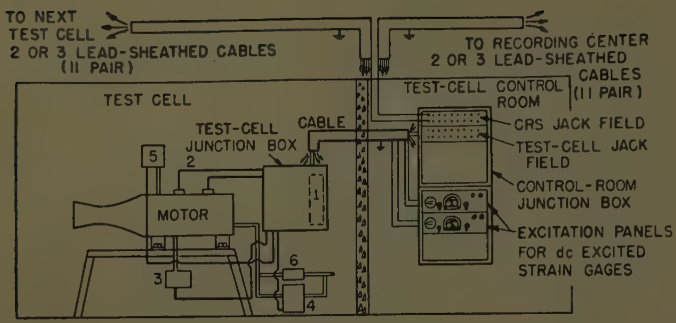

Figure 1(A). A representative installation of a test cell. The numbered components are: 1. Thermocouple reference junction. 2. Thermocouples. 3. Pressure gauge. 4. Flow gauge (differential pressure gauge). 5. Pressure-actuated switch (or other operational indicator). 6. Orifice

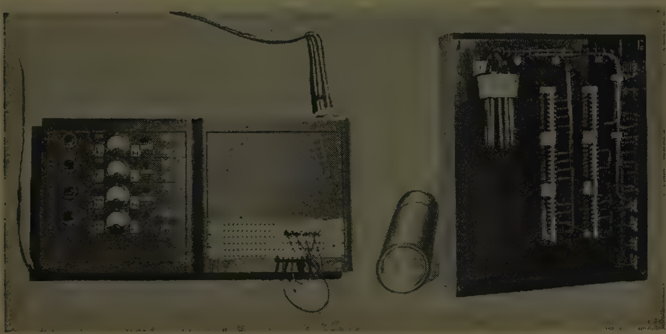

Figure 1(B). D-c excitation panels for the strain gauges and a jack strip (left), and a junction box with Dewar flask used to maintain temperature reference

measurement techniques have been debated warmly, it appears that the accuracies of the two methods are equivalent, being primarily a function of the care and insight used in making the measurements. The advantage of electric instruments is that they offer high time resolution and permit display and recording of data at any convenient and safe location, even though it be remote. In many cases electrical methods are the only means of obtaining the necessary data. Since low-level electric signals are vulnerable to interference and crosstalk, proper shielding precautions must be taken.

DESCRIPTION OF RECORDING SYSTEM

Aerial-Cable Installation. The test cells and laboratories of the Jet Propulsion Laboratory are divided geographically into five groups. Two or three cables connect each group to the recording center. Terminals from all the conductors are brought out to each test cell in the group. The cables are lead-sheathed jute-wrapped telephone cables, each carrying 11 pairs of paper-insulated number 19 American Wire Gauge copper wire. The cable sheath provides effective electrical shielding of the circuits from external interference caused by power and public-address systems. The availability of two shielded cables to each group permits the isolation of high and low signal-level lines. The distance between the recording center and the farthest test location is approximately 2,000 feet. In addition to the shielded cables, two or three twisted-pair lines are suspended along each cable route for use in intercommunication and for control or indication purposes.

Test-Cell Installations. The sensing devices used in the test cells include several types of electric strain gauges and variable-reluctance gauges for the measurement of pressures, differential pressures, flow rates, vibrations, and thrusts. Thermocouples and thermistors are used for temperatures. Switches and small potentiometers are used for mechanical motions. These sensing devices are connected to the system through a standardized junction box immediately adjacent to the work. All circuits from this junction box are terminated in the adjacent control room on a regular telephone-type jack strip, together with the terminations of the aerial cable. The local circuits are conveniently connected to the system at this jack field using telephone-type patch cords. A representative installation is shown in Figure 1*A*, and Figure 1*B* shows the junction box and excitation panels. Every attempt is made to avoid the installation of auxiliary-system equipment at the test locations so that operations can be performed in the recording center in the interest of efficiency. However, excitation panels for d-c strain gauges are frequently mounted in test cells, thereby saving a cable pair for each gauge.

Recording-Center Installations. The equipment in the recording center is mounted in two rows of racks with the recorders on the right side and the intermediate and control equipment on the left, as shown on the front cover of this issue. The recorders are single-channel and multichannel recording potentiometers, recording milliammeters, and two multielement recording oscillographs, shown on the middle table on the cover.

The array of intermediate and control equipment is shown in Figure 2. The third rack from the right is the jack field terminating all the aerial cable pairs, and the adjacent jack field on the left terminates all the inputs and outputs of the recorders and intermediate equipment. Consequently it is quite convenient to synthesize a recording system quickly and connect it to the test-location cable pairs. The recording systems are generally of two distinct types. The first possesses high accuracy and relatively

Figure 2. Intermediate and control equipment panels at the central recording station

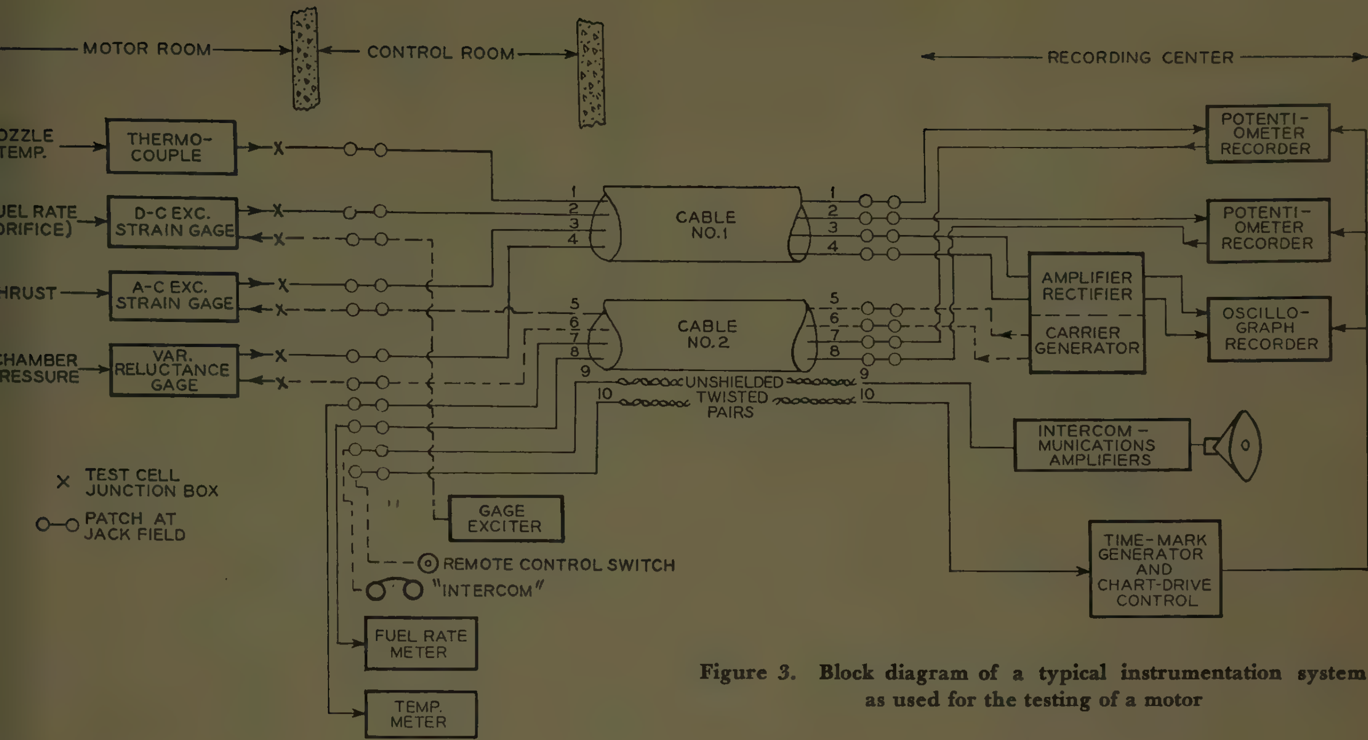

Figure 3. Block diagram of a typical instrumentation system as used for the testing of a motor

oor resolution, and the second, lower accuracy but reatly improved resolution (frequency response). Both ypes are often combined in a single test. The aerial cable airs can be patched into the equalizing panel (shown at he top of the jack field) to correct the total line resistance vhen such adjustment is necessary.

The rack to the left of the jack fields (Figure 2) is an -channel 3,000-cycle-per-second carrier system for use vith electric strain and variable-reluctance gauges. This ystem drives 500-cycle-per-second recording galvanom-ters of the oscillograph. The next rack to the left is a ocally designed 4-channel chopper-type d-c amplifier for lriving milliammeter recorders. The rack adjacent to t is used with a type of flowmeter which generates a signal vhose frequency is proportional to the flow being measured. This rack produces a d-c signal which is linearly propor-ional to frequency. Of the remaining racks, the opera-ions panel is shown at the extreme right in Figure 2, and he control panel adjoins it.

The operation of the recorder-chart drives and chrono-raph pens may be controlled remotely from the test site. The chronograph markers on all recorders are driven imultaneously from a common pulse source of 1, 2, 10, r 60 seconds as selected, thereby time-correlating all ecords with time marks. Any recorder can be switched o any one of three independent remote-control circuits, hereby permitting three independent tests to be recorded imultaneously. The time pulses can be transmitted to he test locations to correlate other recorders used there nd records can be correlated also with respect to events. A monitoring tone is transmitted to the operator at the est site when the recorders are operating.

The operations panel includes a low-impedance milli-olt source for calibrating oscillograph-galvanometer re-ording circuits, a multichannel gauge-excitation panel for -c gauges to be used when the test location is not equipped with individual gauge-excitation units, a hand potentiom-eter which serves as the working standard of voltage, and an excitation control panel to telemetering potentiom-eters. This last-named panel constitutes a very important feature of the system. Small potentiometers are geared to the balancing drives of all the recording potentiometers. These small potentiometers generate a current in the range of 0 to 1 milliampere proportional to the quantity being measured. This current is indicated by meters located in the test cells so that the test engineers may have a display of the values of the quantities being recorded. The rapid telemetering of data to the test-cell operator is an important factor in the operation of the central re-cording system since the successful and safe performance of many tests depends on obtaining information indicated solely by suitable instrumentation. The unit shown at the extreme right in Figure 2 is a 3-channel intercommunica-tion system with volume compression which may be used for simultaneous communication with any three test locations.

Figure 3 is a block diagram representing a typical though somewhat simplified instrumentation system as used for a motor test.

OPERATIONAL PROCEDURES

Because of the heavy traffic of data recording through the central recording station, rules of procedure and regulations for maintaining proper records of all tests are necessary to avoid the misrouting or confusion of records and other mistakes.

Scheduling of tests is necessary. A simple test can be handled within a few minutes when there is open time on the schedule; complex tests may require scheduling in advance. Because of the experimental nature of the rocket-motor tests, with many unknown and unavoidable delays, it is not always possible to maintain rigid schedules.

Through experience, the operating personnel have learned to establish flexible and realistic schedules, thereby reducing delays and conflicts between tests to a minimum.

The synthesis of instrumentation systems and the installation and calibration of sensing devices are handled by an instrumentation field engineer co-operating with the motor test engineer. The field engineer sets up the circuitry in co-operation with the operating staff of the central recording system. After the installation of equipment, the only operations at the test cell at the time of testing include the circuit patching, the setting of gauge excitations when d-c excitation panels are used, and the control of the remote switch for starting and stopping the recorders and time correlators in the recording center. Just prior to tests, all circuits are tested for continuity. The actual test is preceded by a "count-down" to zero time from the test cell to synchronize all operations at the test location and the recording center when necessary. Since the same instrumentation system is often repeated, the motor test personnel frequently perform the test-cell portion of the central recording operations after the original test.

A detailed record of the instrumentation circuitry is kept for each test. This information includes the identification of the sensing devices, aerial-cable-pair numbers, the recorder and recorder-channel numbers, the channel numbers of the carrier system when used, and the variables being recorded. With repeated tests this system can be duplicated each time within a few minutes. Individual records and each channel on all records are properly identified. The data records are forwarded to the test engineer through a prompt mail service. The central recording operations do not include any record analysis or computing processes. However, equipment is being constructed to compute important motor parameters from the signals received during the test. One important parameter is the characteristic velocity, which is proportional to the ratio of motor-chamber pressure to the total fuel flow rates. Computations of motor parameters for immediate indication and recording will materially speed up motor test programs.

Calibrating standards for pressure, temperature, and other variables are maintained as part of the instrumentation service. Instruments are recalibrated at the discretion of either the instrumentation field engineer or the motor test engineer. Immediately adjacent to the recording center is a darkroom where the photographic records of oscillograph recorders are developed immediately after recording.

A maintenance schedule has resulted in a high system-performance record. The calibration of all recorders is checked at the beginning of each week. Patch cords are regularly inspected and tested for poor contacts and high leakage and are cleaned when necessary. Lubrication of mechanical moving parts and replacement of vacuum tubes also are controlled by schedule.

The orderly processes of operations and the maintenance of records and equipment have brought the central recording station to a high level of dependable performance.

SYSTEM PERFORMANCE

Since its initial installation, the system, which was so arranged as to permit easy expansion, has steadily increased the number of tests handled per month. Although most of the measurements are recorded in the central recording station, it obviously cannot be the exclusive means of instrumentation. A number of special portable instruments are equipped with standard jack terminations so that they are connected easily into the circuitry of the test locations where needed.

The low incidence of errors has caused a negligible loss of data compared with those due to the normal equipment failures and maladjustments occurring in experimental work. Since the noise levels of the cables are very low, the error introduced by this source is well below 1 per cent. In general the over-all accuracy of a particular measurement is dependent upon the transducer rather than the cable or recording system.

Since the central recording system at this laboratory has been tailored uniquely to fit a program of rocket testing, no general recommendation can be made as to its suitability for other laboratories. However, it would appear to be an economical technique to apply in any situation where conventional transducers may be used intermittently to measure widely separated phenomena.

Electricity at Work in Industry

Core-and-shaft assembly fixtures at delivery end of electric oven hold rotor assemblies vertical while heated core cools and shrinks to tight fit on shaft. Height of each fixture supports shaft in proper longitudinal relation with core. Production averages more than 100 rotors per hour at the Pittsburgh, Pa., plant of the Westinghouse Electric Corporation

Power-Factor Testing for Finding Insulation Values

J. A. RAWLS
MEMBER AIEE

THE DIELECTRIC-LOSS and power-factor method of testing insulation has been in use by many operating ompanies for almost 20 years for determining when new quipment meets minimum requirements for insulation and keep equipment in use in good operating condition rough adequate maintenance. The equipment for makg dielectric-loss and power-factor tests consists of means r supplying a-c potential to insulation and meters, from e readings of which the power factor of the current rough the insulation may be determined. This test will etect moisture, dirt, carbon deposits, carbonization of ood and other organic material, corrosion of bushing ads due to corona, and almost all insulation defects. The st is not a destructive test since voltages below operating oltage generally are used. The test sets are sufficiently ugged for field use and can be transported easily. Highly echnical personnel are not required to make tests and nalyze the results, but test engineers must have common ense, intelligence, and thorough knowledge of the appaatus being tested.

The Virginia Electric and Power Company has been aking insulation power-factor tests regularly since January 1937. About 1,200 tests a year have been made since at time at a cost of less than $10 each. This cost is justied considering the value of the equipment tested and the efects which are located and corrected before failure. ower-factor tests on the company system were initiated ecause of an epidemic of bushing failures. It was soon ound that the condition of other insulation in transformers, ircuit breakers, and so forth, could be determined easily y the test. Tests were extended to include instrument ransformers, lightning arresters, insulators, H-circuit reaker bushings, voltage regulators, potheads, short engths of cable, small generators, hot sticks, and so forth. hese tests were made in connection with regular mainenance schedules and failures of electrical insulation have een reduced to a practical minimum.

The clearing house principle of pooling the experience f the many companies who are using the power-factor nsulation tests has made data available as to the insulation ower factor to be expected for equipment in various conitions.

In general, the power-factor test results permit classiying the equipment into one of the following groups: . in good condition; 2. in fair condition requiring more requent testing to determine if deterioration is progressing; . in poor condition requiring early maintenance; and . in dangerous condition, unfit for further service until orrected.

Over the past 10-year period the following pieces of equipment with defective insulation have been located with the power-factor test on the Virginia Electric and Power Company system:

Power transformers	180	
Instrument transformers	525	
Oil circuit breakers	464	(mostly bushings)
Lightning arresters	220	(high-voltage station type)
Bus supports	50	(indoor)
Cable potheads	110	

Of the faulty power transformers, about one-third were due to defective bushings and the remainder showed evidence of moisture in the windings. The majority of the instrument transformers which were found with a high power factor were defective by moisture. Bushings were the worst component offenders in the defective oil circuit breakers. A few circuit breakers were found with faulty insulation in the guide members and contact parts. The power-factor test was initiated for lightning arresters after several costly high-voltage lightning-arrester failures. With the present testing methods these failures are now at a minimum.

Defective bus supports were found to have minute cracks on close examination which could not have been found with conventional d-c methods. The predominant cause of cable pothead deterioration was defective gaskets or other seals which admitted moisture to the insulation material.

Present apparatus specifications do not have a specific test for moisture, and moisture is injurious to the insulation both from the standpoint of dielectric and mechanical strength. The power-factor insulation test is especially well adapted to specification purposes because the results of the power-factor insulation tests can be expressed easily.

In addition, the power-factor test is very valuable in the shop for checking component insulation parts of the equipment being worked on to be sure that the insulation is good. New pieces of equipment are given a power-factor test when received from the manufacturer as an acceptance test which establishes the base line for future tests on the same type of equipment.

The dielectric loss and power-factor test has proved itself to be the best for preventive maintenance of insulation. It provides data for an orderly grading of the serviceability of apparatus insulation by comparison with tests and investigations made on similar apparatus insulation since 1929. It is not a destructive test and permits detection of insulation which is a failure hazard before failure takes place. It is a comprehensive test for such contaminants as moisture, since power-factor tests depend only on the insulation materials that are used and not on the amount or configuration.

igest of paper **51-37**, "Power-Factor Testing of Electrical Equipment to Determine nsulation Values," recommended by the AIEE Committee on Instruments and Measrements and approved by the AIEE Technical Program Committee for presentation t the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Not cheduled for publication in AIEE *Transactions*.

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Electron-Tube Heat-Transfer Data

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The heat-dissipating characteristics, as well as electronic characteristics, determine the successful operation of an electron tube. The tube designer, by means of thermal circuits, can evaluate thermal resistances, determine operating temperatures, and find the heat losses, so that he can provide for adequate ventilation.

SUCCESSFUL operation of an electron tube depends on its heat-dissipating characteristics as well as on its electronic characteristics. The tube energy is not all useful, unfortunately, and the part of the total energy that appears as heat must be transferred to the environment. Heat is generated at several sources; the primary sources are at the hottest temperatures, while various structural components assume temperatures intermediate between source temperatures and ambient. All the temperatures are of interest to the tube designer, because of his knowledge of the effect of temperature on the materials with which he works as well as on electron emission.

This article is primarily concerned with operation of the tube in a known environment, although the topics covered are also of importance in tube design. Evaluation of thermal resistance is the principal topic. The equations and formulas to be presented are available in the literature, which will be cited, but not always in a form convenient for use in electrical problems.

It is possible to estimate the temperature at any location in a tube due to the losses it generates by means of the well-known device of a thermal circuit. James Clerk Maxwell[1] was the first to point out the analogy between conduction of electricity and conduction of heat. He wrote, in part, "The analogy between the theory of the conduction of electricity and that of the conduction of heat is at first sight almost complete. If we take two systems geometrically similar, and such that the conductivity for heat at any part of the first is proportional to the conductivity for electricity at the corresponding part of the second, and if we also make the temperature at any part of the first proportional to the electrical potential at the corresponding point of the second, then the flow of heat across any area of the first will be proportional to the flow of electricit across the corresponding are of the second. . . . Flow o electricity corresponds to flov of heat, the electric potentia to temperature, and electricity tends to flow fron places of high to places of lov potential, exactly as heat tend to flow from places of high to places of low temperature."

The thermal circuit is thus analogous to an electri circuit, with current replaced by heat flow rate, voltag replaced by temperature difference, and resistance re placed by thermal resistance. It is no longer considere necessary to have geometrical similarity, and the procedur may be extended to the case of transient heat flow, by re placing electrical capacitance with thermal capacity.

The natural mode of heat dissipation from the surfac is by free convection and radiation; at room temperatur the magnitude of these two effects is about the same When the tube runs too hot, recourse must be had to force convection, in which a cooling fluid, usually air or wate is forced over the surface by mechanical means. In som special applications the tube is required to operate in fixed temperature range.

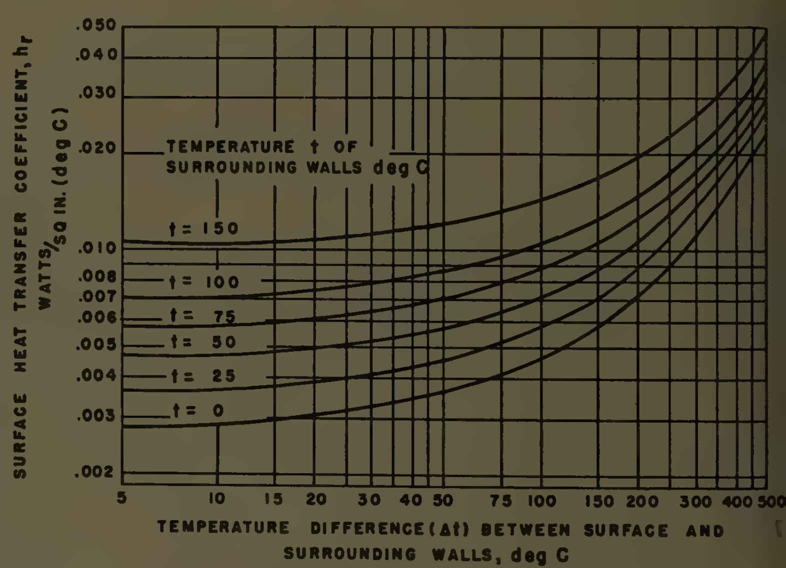

Figure 2. Surface heat-transfer coefficient for radiation, with emissivity 0.

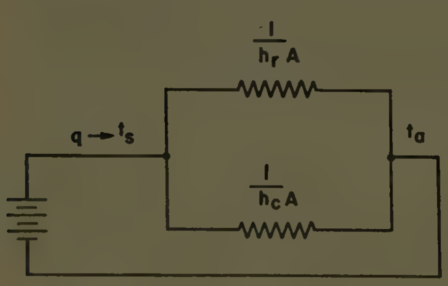

Figure 1. Thermal circuit for a tube envelope

Essential substance of paper 51-227, "Basic Heat-Transfer Data in Electron Tub Operation," recommended by the AIEE Committee on Electronics and approved b the AIEE Technical Program Committee for presentation at the AIEE Summer Gener Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Scheduled for publicatio in AIEE *Transactions*, volume 70, 1951.

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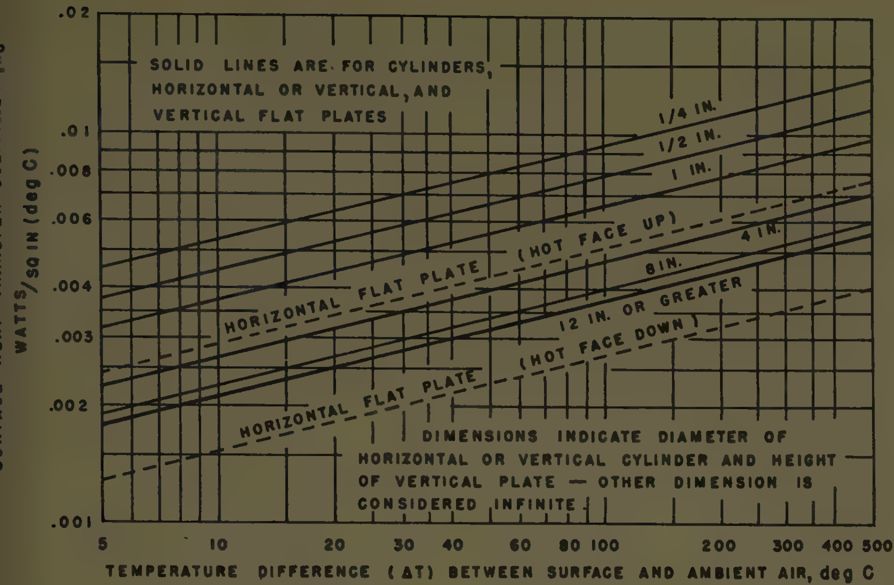


igure 3. **Surface heat-transfer coefficient for free convection in air, cylinders, and flat plates**

The complete thermal circuit for heat dissipation from . tube consists of a network which is evaluated in the rdinary manner by means of Kirchhoff's laws or similar heorems. However, any element may be evaluated eparately if heat flows or temperatures up to the point f consideration are known.

The first circuit to be illustrated gives the temperature f a tube envelope, cooled by radiation and free convecion, when the heat generation and the ambient temperaure are known (Figure 1). The heat generated in the ube must be known; the losses are the space charge loss, he filament power, and the grid loss. Any other expected osses should be included.

Heat transferred by radiation is proportional to the ourth power of the temperature. The net radiation etween two surfaces, one of which is relatively small nd surrounded by the other at a different temperature, is lotted in Figure 2. For convenience this function is lotted for $e=0.9$, a value which is a fair average for glass, or painted surfaces, and for well-oxidized metals. For ases where the surface emissivity is known accurately, he heat-transfer coefficient is adjusted by multiplying by he ratio of the known emissivity to 0.9.

FREE CONVECTION

THE FREE convection coefficient for air is plotted in Figure 3. The basic equations, which are to be found n McAdams,[2] have been plotted in this curve in electrical nits.

The free convection curves are drawn for air at atmosheric pressure with average temperature of surface and mbient 65 degrees centigrade. To correct for other ressures, as in high-altitude operation, the coefficients nust be multiplied by the square root of the ratio of the perating pressure to standard atmosphere.

For other fluids, no simple general and precise relation vill suffice, because of the wide variation of properties mong fluids, and also the variation with temperature of the properties of any one fluid. However, useful correlations are available in McAdams.[2]

Fins. If calculations on the basis of Figures 2 and 3 indicate that the tube wall will run only a little too hot, some expedients may be tried before forced cooling is resorted to. One possibility is the use of fins, or other extended surfaces, where the tube configuration will allow their construction.

Fin effectiveness η for fins of uniform section is plotted by Harper and Brown.[3] The abscissa, αb, is determined from Figure 4 according to

$$\alpha = \sqrt{\frac{hA_s}{kA_0 b}}$$

where h is the surface heat-transfer coefficient for radiation and conduction; k is the thermal conductivity of the fin material; A_s is the fin surface area; A_0 is the fin cross-section area; and b is the fin height.

Several factors must be considered in the use of fins. In the first place, the fin characteristic known as "fin effectiveness" must be high, because this is the quantity that determines how closely the fin surface temperature approaches the fin base temperature. In addition to this, the radiation part, h_r, of the heat-transfer coefficient applies only to the envelope of the heat-dissipating area. The usual values of free convection coefficient h_c are valid only if the spacing between fins is great enough for free convection to take place effectively. A rule-of-thumb states that free convection tends to be seriously suppressed with spacings less than a quarter of an inch.

Chimneys. Another possibility of increasing the natural convection lies in the use of a shield to introduce a chimney effect. Some tubes are shielded for electronic reasons; the efficacy of the shielding will not be impaired by coating the shield with material of high emissivity, and the heat

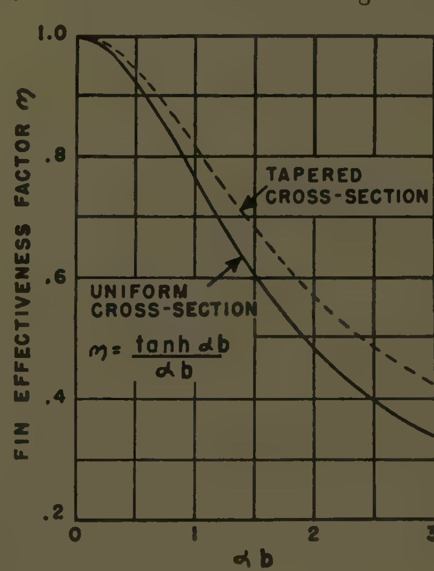


Figure 4. Effectiveness of fins on flat surfaces

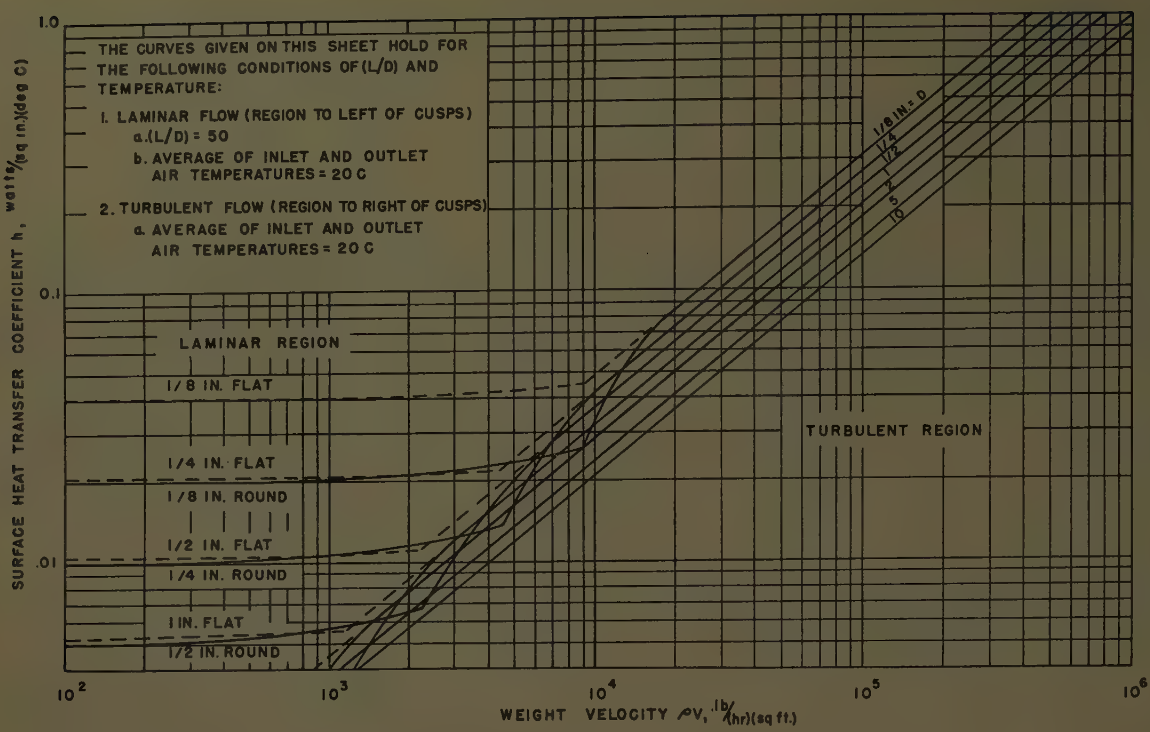


Figure 5. Forced-convection coefficient for air in smooth straight ducts

dissipation will be increased. Moreover, the air space between tube and shield is normally small, so that convection does not take place; opening up the gap to permit air flow will result in further cooling. The same possibility is present in the case of tubes not usually shielded. Here the spacing is extremely important, as the area for air flow must be large enough so that the head produced by the difference in density is not all used up in overcoming friction, and small enough for the increased air velocity to be effective in increasing heat dissipation.

FORCED CONVECTION

The values of forced convection heat-transfer coefficients depend on the character of the flow, whether laminar, turbulent, or in the transition region between these two well-defined types. The basic work on charac-

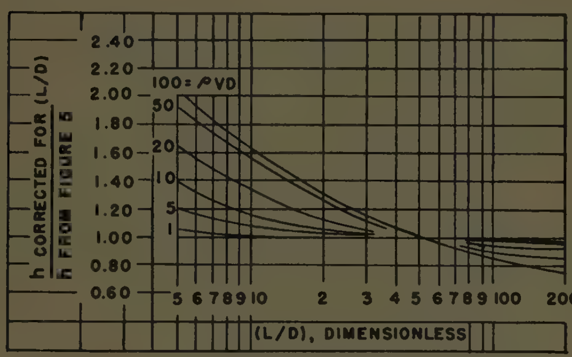


Figure 6. L/D correction factor for laminar flow of air in round ducts

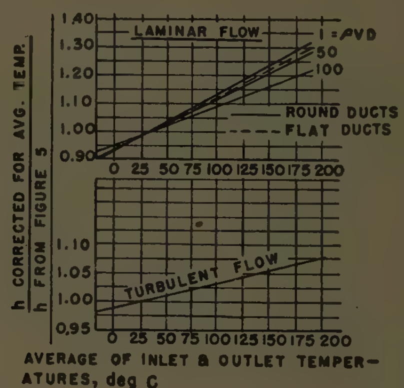


Figure 8. Average temperature correction factor for flow of air in ducts

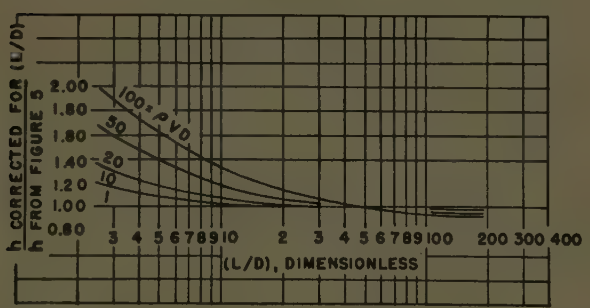


Figure 7. L/D correction factor for laminar flow of air in flat ducts

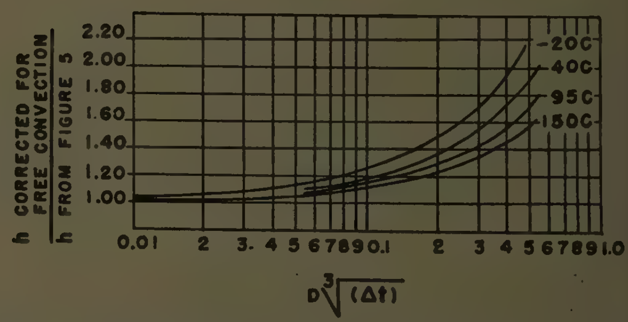
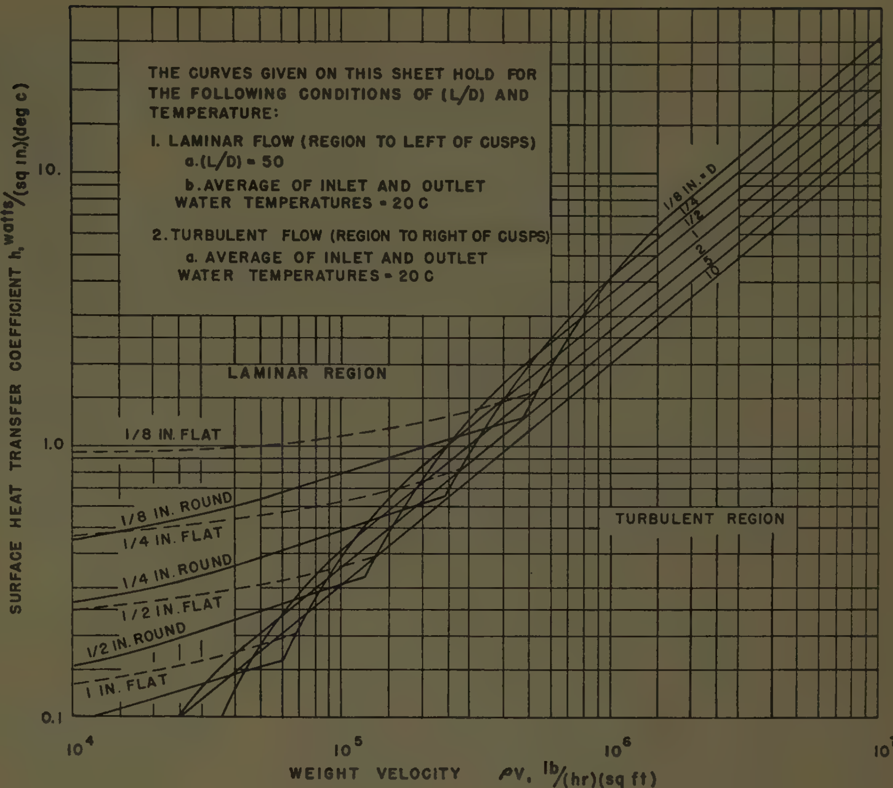


Figure 9. Free-convection correction factor for laminar flow of air in ducts



igure 10. **Forced convection coefficient for water in smooth straight ducts**

er of flow was done by Osborne Reynolds,[4] and the Reynolds number which bears his name gives the criterion for flow. He studied the effect of varying water velocity in a straight glass tube, introducing ink at the center, and photographing the flow pattern. For low velocities the ink proceeded down the tube in a straight line; for high velocities it immediately colored the whole fluid; and for intermediate velocities it produced a wavering pattern. He was able to establish the velocity at which laminar flow ended, and the velocity at which turbulent flow was fully established. The Reynolds number, which is dimensionless, has been a basic parameter in evaluating forced-convection coefficients ever since.

General dimensionless correlations of heat-transfer coefficients in terms of properties, dimensions, and velocities are available in the literature[5–8] for gases and for liquids of low viscosity. It is to be expected that a general relationship applying to all fluids will be subject to error, and as a matter of fact heat-transfer coefficients determined from the general equations may be in error by ±30 per cent. However, being in error by ±30 per cent is better than being in error by two-to-one or ten-to-one.

Forced Convection for Air and Water in Ducts. Since fluid properties are well known for air and water, it is possible to plot forced-convection heat-transfer coefficients as watts per square inch-degree centigrade against weight velocity of the fluid. Figure 5 gives the heat-transfer coefficient for air in smooth straight ducts for the conditions specified on the figure, and is to be used with log-mean temperature difference. Figures 6, 7, and 8 give the correction factors to be applied when the operating conditions differ from those specified in the figure, while Figure 9 gives the free-convection correction factor.

Figure 10 gives the heat-transfer coefficient for water in smooth straight ducts. Figures 11, 12, and 13 give correction factors to be applied as in the case of air, except that

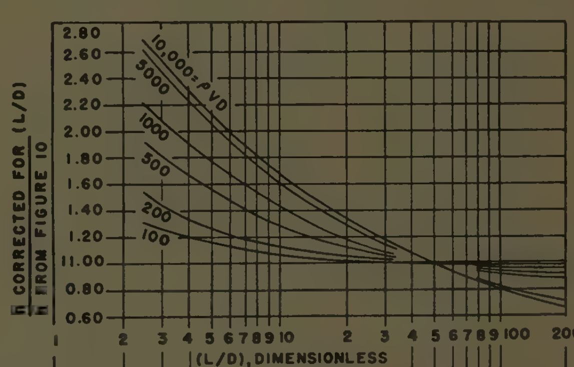
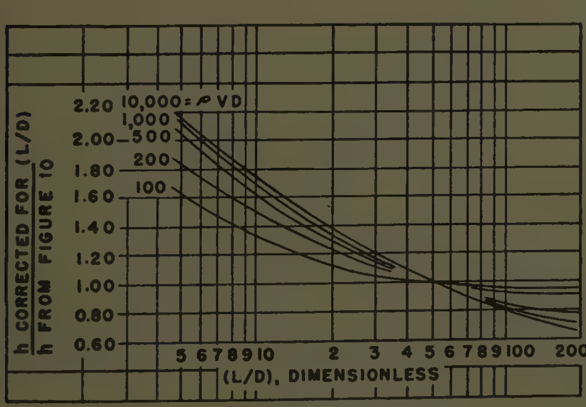


Figure 12. L/D correction factor for laminar flow of water in flat ducts



igure 11. **L/D correction factor for laminar flow of water in round ducts**

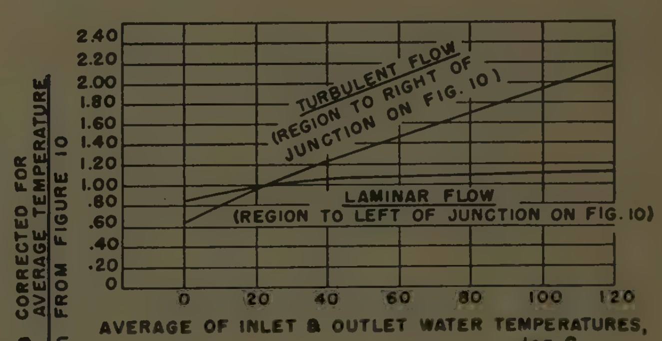


Figure 13. Average temperature correction factor for flow of water in ducts

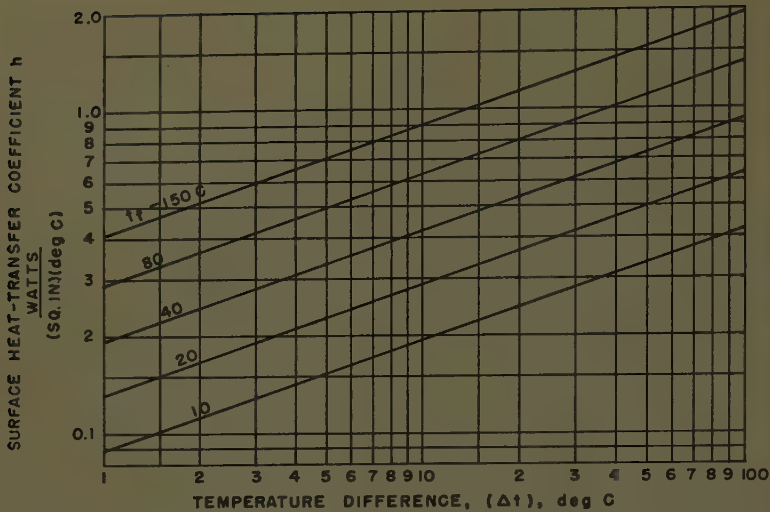


Figure 14. Free-convection heat-transfer coefficient for water in ducts

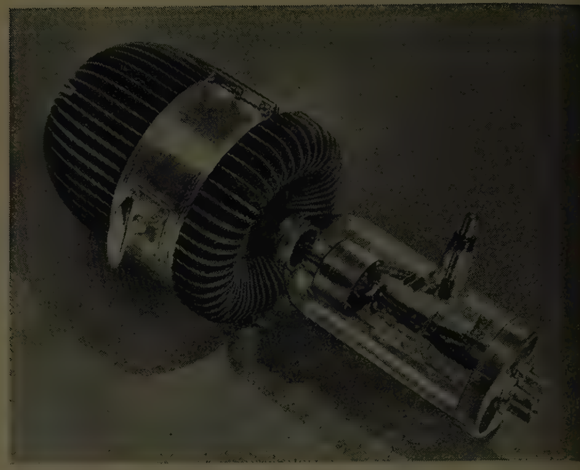


Figure 16. An 892-R triode with fins for dissipating heat

the average of inlet and outlet water temperatures is 20 degrees centigrade. Figure 14 gives the curve for free convection. In case of doubt as to which curve applies, determine h from both and use the higher.

Pressure Drop in Forced Convection. Pressure drop in a pipe is given by the relation

$$\Delta p = 4f\frac{L}{D}\,\frac{\rho(V'')^2}{2g}$$

Where p is pressure drop, pounds per square foot; f is the Fanning friction factor, dimensionless; L/D is the length to diameter ratio, dimensionless; ρ is density, pounds per cubic foot; V'' is velocity, feet per second; and g is 32.2 feet per second per second.

For turbulent flow the friction factor is very nearly constant, which means that for a given configuration the pressure drop varies nearly as the square of the velocity. Since the heat-transfer coefficient varies as the 0.8 power of the velocity, it is obvious that high heat transfer can only be obtained at the expense of pressure drop. In deciding what velocities to use, the balance must be economic. That is, the size of blower or pump must be balanced against the gain in heat transfer.

Enclosure Ventilation. In many cases the tube with associated equipment is enclosed in a container. The question then arises as to how much hotter the tube will run. If the container is tightly closed and is dissipating heat by radiation and free convection, the temperature rise may be estimated from Figures 2 and 3. The thermal circuit is shown in Figure 15, where subscript t refers to

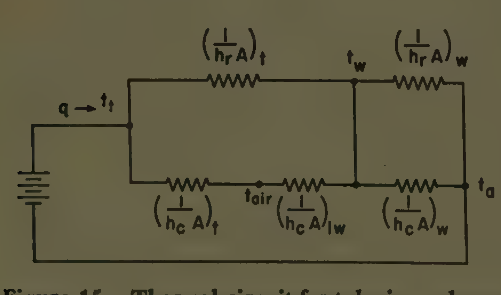


Figure 15. Thermal circuit for tube in enclosure

tube, iw to inner wall, w to outer wall, and a to ambient.

The heat from all the sources must be dissipated through the walls of the enclosure. The first step is to evaluate the wall temperature, which is done as before, by cut-and-try. The surface temperature is independent of the sources within the enclosure, except perhaps for local heating due to close proximity of one of the sources.

When the surface temperature has been evaluated, the tube temperature and the box air temperature may be calculated. Radiation goes directly from the tube to the wall, while convection heats the air and must be evaluated for both surfaces. Opening up the box by louvers or holes at top and bottom edges will produce a chimney effect which will lessen the temperatures. The chimney effect is a function of the height of the opening above the heat source, and is, therefore, less effective if holes are punched throughout the walls.

Figure 16 shows the construction of the *892-R* triode.[9] Calculation of the hot spot by the foregoing method gives a value slightly less than obtained by test, and calculation of the pressure drop gives a value which, when added to the entrance and exit losses, gives the required head.

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Inhibited Oils for Transformers

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ALLOWABLE AND actual loadings of transformers of the Commonwealth Edison Company have increased nsiderably in the past 15 years with consequent rises in insformer temperatures. Oils with improved oxidation ibility have gained increased importance, especially for der type transformers in service. An immediate interest veloped in inhibited oil when it became commercially ailable in 1946, and a program of tests was initiated at at time to determine the extent of its superiority.

The first series of tests compared one specific inhibited with conventional oil when used as replacement oil in insformers of the unprotected type, where the access of to the oil is not restricted. The test setup consisted of ir distribution transformers. To study the effect of insformer deterioration on the aging of replacement oil, o were new 15-kva transformers; the other two were d 10-kva transformers which had been in service for 22 ars, and which had been reconditioned by cleaning the re and coils and flushing with clean oil. Access of air the oil was permitted by having the covers resting on the p of the cases without being bolted down.

One new and one old transformer were filled with hibited oil and the other two with conventional oil. ie transformers were operated throughout the tests at a p oil temperature of 90 degrees centigrade, with not more an 1-degree variation regardless of sludging. The insformers were allowed to cool down once a week to ovide for breathing action.

The aging tests lasted 42 months. The performance of e oil was judged from tests of samples removed periodically om the transformers and from inspection and tests of the insformers after completion of the aging tests. Figure 1 ows the results of periodic tests of sludge content of the , one of several criteria by which the deterioration of the was determined. The limit of serviceability on the basis sludge content of 0.015 per cent, according to Common-ealth Edison Company standards, is indicated by a rizontal line. This limit was reached for conventional after 12 to 14 months, and for the inhibited oil after 27 40 months. On the basis of these data and other criteria oil deterioration, the service life of this specific inhibited can be expected to be two to three times the life of con-ntional oil when used as replacement oil.

In addition, laboratory stability tests of relatively short iration were made, some of which lasted up to 107 days. iey indicated a life for the one specific inhibited oil of to as much as 18 times the life for conventional oil. It believed, however, that the simulated service-aging tests transformers give a more realistic idea of oil performance

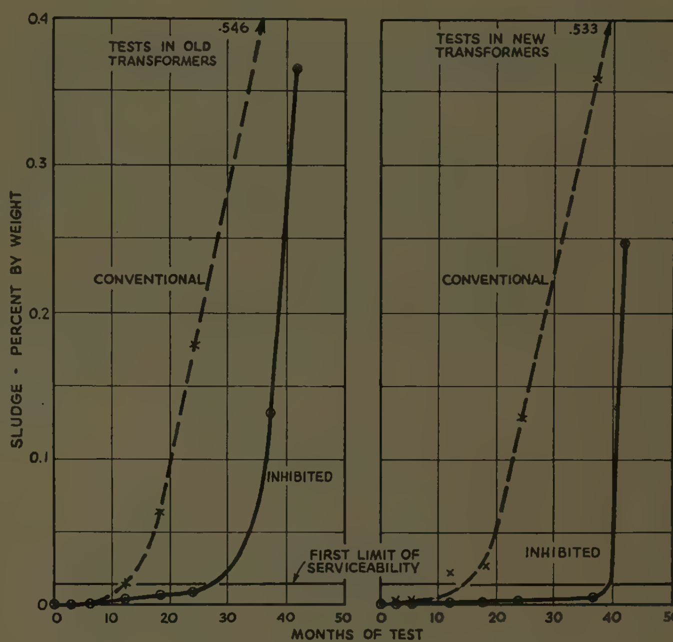

Figure 1. Sludge content of oil in transformer tests

because in these tests the accelerated aging was achieved largely by a high load factor of operation, and the temperatures were not so far in excess of service—operating conditions to produce deterioration materially different from deterioration under service conditions.

At the end of the 42 months of aging, two 15-kva transformers were subjected to a heat run at rated current. The transformer aged with inhibited oil had a temperature rise over ambient of 50 degrees centigrade for the high-voltage winding, 47 degrees centigrade for the low-voltage winding, and 39 degrees centigrade for the top oil. The transformer aged with conventional oil had corresponding temperature rises of 113, 90, and 46 degrees centigrade, respectively. These results illustrate an important advantage of inhibited oil; that is, by preventing the formation of sludge, transformers may be operated at heavy loads without the likelihood of reaching excessive temperatures.

Visual examination at the end of the aging tests revealed, for the transformers aged with conventional oil, heavy sludging resulting in complete obstruction of the oil channels. For the tests with inhibited oil there was no sludging in the new and some sludging in the old transformer, but in both the oil channels were unobstructed.

On the basis of these results, inhibited oil has been used by the Commonwealth Edison Company since July 1950 as the replacement oil for transformers.

Similar aging tests in ten transformers are in progress to determine the stability of other inhibited oils and to compare the performance of such oils with conventional oil in completely sealed, or conservator-type, transformers.

gest of paper **51-208,** "Inhibited Oils for Transformers," recommended by the EE Committee on Transformers and approved by the AIEE Technical Program mmittee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, nada, June 25–29, 1951. Scheduled for publication in AIEE *Transactions*, volume 1951.

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An Engineering Approach to Control Room Lighting

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MODERN CONTROL ROOMS in utility and industrial power stations are nerve centers of multimillion-dollar operations. Lighting for these important work areas can be provided in various ways depending upon what limits are assigned the task. If one considers the medium of lighting as a small but important part of the power plant entity and it is recognized that over-all economy is the result of economical parts, then the search for an adequate lighting scheme narrows considerably.

From the illumination engineer's standpoint, the following fundamentals must be observed to effect good lighting.

1. Vertical illumination on the instrument board should be adequate for quick, comfortable visibility of the many relatively small scales within glass-faced instruments.
2. The illumination on the vertical plane should be diffused to minimize shadows on the instrument scales.
3. The light sources must not present themselves as images of specular or veiling glare in the glass faces of instruments from operators' usual working positions.
4. The light sources must not present themselves as brightness areas in competition with the object being observed, namely, the instrument scales.
5. The brightness contrasts between various surfaces in the operators' normal fields of view should not cause the visual surroundings to be uncomfortable.
6. The degree of perfection obtained in each category should be balanced by the cost of each incremental gain.

Before the introduction of fluorescent lamps, power plant control rooms utilized all recognized forms of incandescent lighting systems. The many advantages of fluorescent lamps have gradually made them the preferred sources for control rooms and especially in luminous ceiling systems having indirectly lighted ceilings, louvered ceilings, or solid luminous ceilings; and in direct systems with ordinary flush troffers (open, louvered, glass panel, and lens), and ordinary troffers in a specially designed ceiling. In general, the luminous ceiling systems minimize shadows on the instrument boards whereas the ordinary direct systems would tend towards harsher shadows. The latter system, however, projects light more efficiently upon specific working surfaces. Special direct systems possess the advantages just mentioned and, in addition, can be designed to make shadows negligible. Such a system is illustrated in Figure 1.

One major point of variance in control room lighting objectives is the level of illumination that is deemed necessary. The vertical illumination level rather than the horizontal level is the most important to consider. Control rooms have been observed in which the general horizontal illumination level was only 5 foot-candles. In this particular case, the vertical illumination level was even less. Yet, the operators did not hesitate to respond that the level was entirely satisfactory. The type of control room, whether it is for limited control of turbogenerator auxiliaries or for centralized control of many units, whether it is large or small, has a bearing on the required vertical foot-candle level. In general, the writer has established that 20 foot-candles on the vertical surface of the control board, approximately 60 inches above the floor, is adequate for present-day centralized control rooms. The same level on the horizontal plane of the operator's desk is also sufficient for the visual task involved. Levels higher than 50 foot-candles on the vertical plane and 100 foot-candles on the horizontal plane have been recommended by others. The higher the level the more costly the installation. Justification of such high levels for control room visual tasks is difficult to conceive.

There are many possible solutions to the control room lighting problem, each with merits based on specialized requirements. The lighting system illustrated uses commercially available troffers in conjunction with a special ceiling design.

Figure 1. Normal lighting in a control room having direct lighting and a special ceiling design

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Industrial Plant Power Sources

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Many types of industrial plants can generate their own electricity economically under certain conditions. Such conditions, and various methods for making the most of them, are set forth in this article.

NO PRETENSE WILL be made in this article of treating the broad subject of industrial plant power sources in a comprehensive way. Rather, the in- ntion is to take a quick look at all phases of the matter to scover, if possible, trends in one direction or another, amine the latest practices r technical advancement, id present pertinent eco- omic data when available. ypical examples of the new- t in industrial power plants several widely different in- ıstries will be described iefly, and novel features ointed out. For more detailed discussions reference ıust be made to the list of sources given at the end of is article.

Power sources for industrial plants fall naturally into one two general classes: public utilities and governmental gencies; and company-owned generating facilities.

Industry is progressively generating a smaller part of its wn demand. According to one source, industry generated) per cent of its power requirements in 1939, only 33 per ent in 1948, and it was estimated that the figure will drop 30 per cent by 1955.[1] A more recent figure based on ie census data of 1947 indicated that industrial plants then ere generating only 17 per cent of their power require- ients.[2] No matter which figures are more nearly correct, ie trend toward purchased power seems evident.

Whenever power is needed for an industrial plant, the use purchased power must be considered carefully. The ctors which influence the choice of an industrial plant ower source are so many and varied that it would be im- ossible to discuss all of them here. However, it may be ated generally that wherever adequate amounts of urchased power are available at reasonable rates, pur- iased power almost certainly will be the most economical ource unless there are special features of the industrial lant requirements. Some of these special features are:

1. Heat needed in processes.
2. Heat available from processes.
3. Very large power demands.

These features will be discussed and some of the most ecent means employed to provide economical power sup- lies in specific plants will be described.

PLANTS NEEDING HEAT IN PROCESSES

MANY TYPES of industrial plants belong in this category including chemical plants, paper mills, oil refineries, nd some manufacturing plants. It can be said almost xiomatically that where steam at relatively low temperature and pressure is needed in a process, as in many chemical plants, the power required can be generated at very low cost in topping units from steam produced at higher temperature and pressure than is needed for the process. Initial steam pressures utilized to date have gone as high as 1,250 pounds per square inch gauge, and initial temperatures as high as 900 degrees Fahrenheit. For small plants steam engines have been widely used as topping units, while for larger plants steam turbines of all types can be found, ranging from straight noncondensing to multiple-extraction condensing units. Depending upon fuel and other costs, the actual out-of-pocket cost of the power thus generated may be as low as 2 mils per kilowatt-hour, or even less in the most favorable cases.

Perhaps the most outstanding example of a power plant of the type under consideration is the South Power House of the Dow Chemical Company at Midland, Mich. In size and design this power plant compares favorably with the latest public utility plants. Two 400,000-pounds-per-hour steam generators and one 30,000-kw turbogenerator form the initial unit which was placed in full operation on June 21, 1950. Figure 1 gives a view of the power plant and coal

Figure 1. South Power Station of the Dow Chemical Company, Midland, Mich.

handling facilities. From the operating point of view the plant is designed with nearly ideal lighting, ventilating facilities, and convenience. The building proper is so designed that the boilers and turbogenerator are contained within one room, with the boilers, boiler control panels,

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Figure 2. Firing aisle showing cyclone burners, South Power Station

Figure 3. 30,000-kw turbogenerator and auxiliaries, South Power Station

boiler feedwater pumps, and turbogenerator so arranged on the operating floor that a minimum of personnel is required on each shift. Additional space is provided in the building structure for two additional boilers and one additional turbogenerator unit.

Aside from the size of the boilers and turbogenerator and from the operating steam pressure of 1,250 pounds per square inch, there are several novel features involved in the South Power Plant which deserve mention. One of these is the use of cyclone furnaces in which crushed coal carried in a high velocity stream of preheated air is introduced on a tangent through cylindrical primary burners at the furnace ends. Centrifugal forces in the spiralling mass throw out the coarser coal particles to a thin layer of molten slag coating the inside of the furnace where they are rapidly burned by the scrubbing action of the high-velocity secondary air admitted tangentially along a part of the furnace length. Actual combustion of solid coal and combustible gases is said to be complete when the gases leave the cyclone furnace and enter the primary furnace which is located in the boiler proper.

Another unusual feature is the use of completely pressurized furnaces. Induced draft fans are eliminated entirely and all air requirements are met by high-efficiency, axial-flow, variable-pitch blowers. Three such blowers are provided, each driven by an 800-horsepower d-c motor, with two in operation. Elaborate sealing arrangements are needed in the boiler to prevent gas leakage, including the installation of 60-pounds-per-square-inch air jets which blow back the flames when small access doors to the furnace are opened.

Figure 2 shows the firing aisle at the front of the boilers and gives a good view of the completely water-cooled cyclone burners. It is worth noting that on account of the very thorough heat recovery, the expected over-all efficiency of the steam generators is better than 90 per cent.[3]

Hydrogen cooling of the turbogenerator shown in Figure 3 is certainly not common in industrial plants but becomes economically attractive in a machine of this size. As a matter of fact, this 30,000-kw turbogenerator is the largest double-extraction unit ever built. In the foreground two boiler feed pumps can be seen, one motor-driven and the other turbine-driven. Figure 4 gives a good view of the console control board and boiler control panels. Above the boiler board at the left can be seen a uniscope television set which permits observation of hot slag drainage from the primary into the secondary furnace. The thought put into the design of the control boards is reflected in the compact arrangement and neat appearance.

Looking at the simplified steam flow diagram in Figure 5, it will be seen that steam is bled from the turbine at 425 and 165 pounds per square inch gauge pressure as required in the process, and exhausted at 25 pounds per square inch gauge pressure. Maximum flows at each pressure are indicated but, of course, these maximum flows cannot be taken simultaneously at all pressures. Exhausts from the turbine-driven boiler feed pumps and forced draft blowers go to the 25-pounds-per-square-inch pressure mains, the steam from which is used for boiler feed water and building heating, and for miscellaneous services.

From the foregoing description it is clear that one commonly used measure of power plant investment, namely cost per installed kilowatt, is not applicable to plants of this type. In a base-loaded central station, the boiler

Figure 4. Duplex control board at the South Power Station

pacity here installed could furnish steam to generate proximately 90,000 kw as compared to the 30,000-kw :bogenerator actually installed. Computing the cost per owatt on the basis of the installed generating capacity a plant such as the South Power Station would result an inordinately large, and hence misleading, figure.

Other means of providing heat for process than steam ilers and turbines are in use. One notable installation is at of a mercury boiler and turbine at the Pittsfield Works the General Electric Company.[4] In this case additional wer and a considerable amount of steam at 640 pounds r square inch gauge pressure were required. The use of a 500-kw mercury-unit power plant enabled the generation 7,500 kw of power and 113,000 pounds per hour of steam the desired temperature and pressure, and the required tio of electric power to steam production was obtained. ɔ steam-turbine topping unit could have met these re- irements.

Figure 6 shows a heat-balance diagram at rated load for e Pittsfield installation. Note that the ratio of electric neration to steam produced is 66.5 kilowatt-hours per 000 pounds. Passing the steam flow from the mercury iit to existing extraction turbines results in a net over-all heat rate of 10,800 Btu per kilowatt-hour or a thermal efficiency of about 32 per cent, which is remarkable for a plant of this capacity.

The gas turbine offers some interesting possibilities for generating power and furnishing heat requirements.

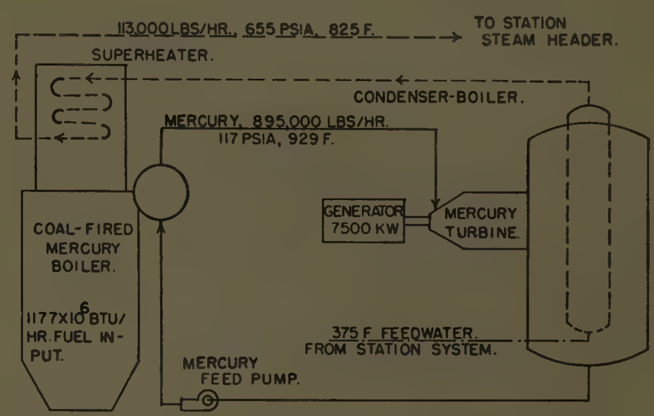
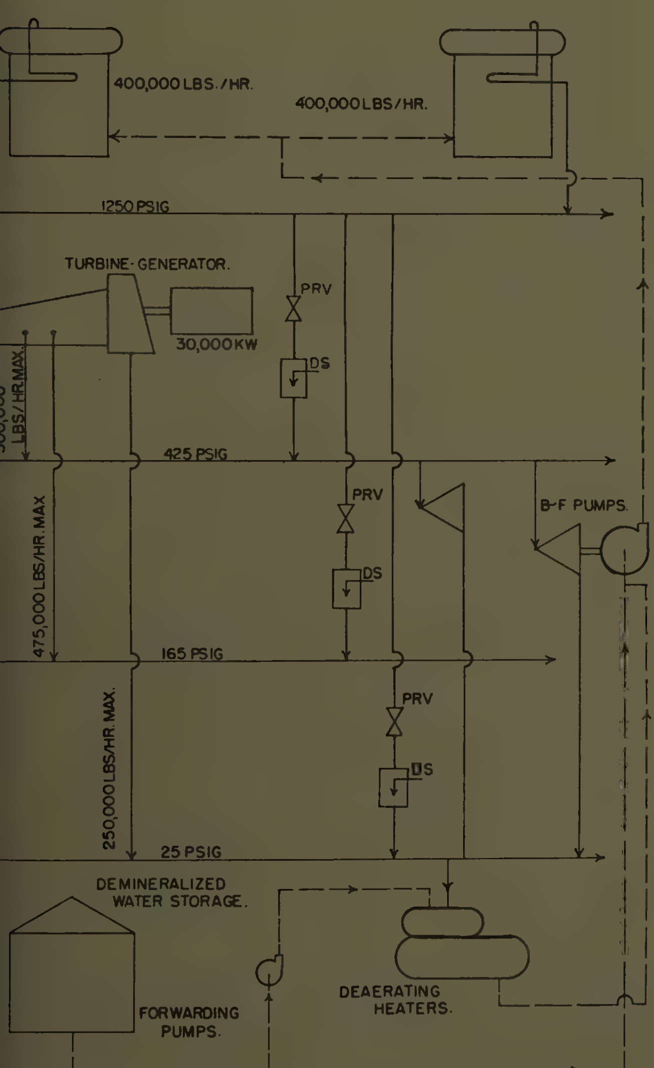


Figure 6. Simplified heat balance at rated load, General Electric Company, Pittsfield, Mass.



gure 5. Simplified flow diagram of the South Power Station

Although no industrial applications appear to have been made to date, one central station installation might be mentioned as indicative of possible use in industry. At the Huey station of the Oklahoma Gas and Electric Company, a simple-cycle gas turbine in conjunction with a recuperator used for feed water heating from turbine exhaust gases has been running very satisfactorily for more than a year.[5] Operating in conjunction with the steam station, the gas turbine reduces the over-all heat rate and increases the total capability. An increase of 7,400 kw in total capability for station at maximum load was obtained at an installed cost of less than $100 per kw. The incremental heat rate for the gas turbine unit is 12,000 Btu per kilowatt-hour.

At the present time it appears that gas turbines cannot compete with efficient steam or Diesel generating plants because of the high first cost of units with efficient heat cycles, as well as fuel limitations. Where low cost gas or oil is available a simple-cycle low-cost gas turbine may have a place, particularly if heat can be recovered from exhaust gases.[6]

It is in order to mention here a proposal which has been made to apply gas-turbine technique to steam power.[7] Briefly, the idea is to use superheated and compressed steam as the gaseous medium in a gas turbine instead of the usual gases of combustion. A portion of the exhaust steam from this turbine is then available to do work in a conventional condensing turbine and, after being condensed, is added to the remainder of the exhaust from the gas turbine to desuperheat the steam. The desuperheated steam then is compressed, superheated, and sent back to the gas turbine. Using this cycle with 1,200-degree-Fahrenheit entrance steam temperature, and appropriate regenerators and air preheaters, the author computes a net plant efficiency of 40.85 per cent. With 1,600-degree-Fahrenheit entrance temperature, the net plant efficiency is calculated at 48.2 per cent. Such efficiencies seem to be theoretically

possible but there are practical difficulties involved in the operation of compressor, superheaters, and regenerators at the temperatures and pressure needed which, if not insoluble, certainly would make the cost of such installations enormous. Until some actual economic and operating data are available, this scheme cannot be of more than academic interest to industrial power plant engineers.

A case which frequently arises, especially in connection with chemical plants, is that in which an excess of power over and above the plant requirements can be generated economically by the steam needed for process. When such a condition occurs, an arrangement can often be worked out with the local public utility to sell the excess power to it at cost in return for a stand-by connection without the usual expensive charge. Both the industry and public utility can benefit by such an arrangement, not only from a cost standpoint, but also from the help that each may be able to give the other in emergencies.

Another condition is that in which the public utility undertakes to furnish steam for process use as well as power. A good example of such service is that of the Gulf States Utilities Company sales to the industrial area of Baton Rouge, La.[8] In another instance an industrial center in East Newark, N. J., supplies steam and power to 40 independent and diversified manufacturing firms within a small area.[9]

PLANTS HAVING HEAT AVAILABLE

To simplify the classification there have been included under this heading all plants which may have heat available for power generation, whether in the form of

Figure 7. Engine room, Aluminum Company of America, Point Comfort, Texas

waste heat directly from the process or in the form of by-product fuel. Many chemical plants, paper mills, sugar cane refineries, saw mills, and the like may have heat available in some form or another. However the steel industry tops them all in this respect and the discussion here will be confined to this industry.

A large and well-integrated steel plant will have waste heat and by-product fuel in the shape of blast furnace gas and coke oven breeze over and above the plant needs, an this fuel can be burned in boilers to produce a large amoun of power. Coke oven gas and tar may also be available bu it is usually more economical to burn this fuel elsewhere i the plant or sell it. Considerable low-pressure steam is re quired for process and heating, and the demands for powe are also very large. Designing a suitable power house fo such a plant will necessitate a thorough knowledge of a steam and power demands, as well as of the by-product fue availability.

Ordinarily it will be found advisable to generate stear with the by-product fuel up to the maximum at all time It usually will be desirable to generate this steam at som higher pressure than would be needed in the plant and sup ply the plant steam requirements through noncondensin turbogenerators, thus obtaining a portion of the plan power requirements at a very low heat rate. The balanc of the high-pressure steam then can be used to generat power in condensing turbogenerators. Generally the plan power requirements will be in excess of what can be sup plied economically by the steam plant. In most cases thi excess power is best purchased from public utilities.[10]

A number of power plants have been or are being buil for steel plants. Time will not permit detailed descriptio of any one here but attention may be called to the trend t high temperature and pressures, as well as to the large siz of some recent installations. For example, the Carnegie Illinois Steel Corporation is just completing an installatio in a plant near Chicago which consists of a 650,000-pound per-hour steam generator and a 60,000-kw turbogenerator.[1] The boiler burns blast furnace gas and the steam condition are 1,025 pounds per square inch gauge pressure and 90 degrees Fahrenheit total temperature. Turbogenerato speed is 3,600 rpm and the turbine exhausts at 29 inches c vacuum with five bleed points for feed water heating Hydrogen cooling is employed in the generator.

VERY LARGE POWER REQUIREMENTS

Some industries are such large consumers of power tha their demands are comparable to those of public utilitie These industries may elect to generate their own powe requirements on the grounds that they can build the neces sary power plants at as low costs and operate them a efficiently as the public utilities. If the needs of any indus try dictate the location of its plants at points where larg blocks of public utility power are not available except ove long transmission lines, the proposition becomes increas ingly attractive, particularly if extreme reliability of servic is of prime importance in the operation of the plants.

The electrochemical industry is characterized by its dis proportionately large use of power as compared to othe types of industries. In this group the aluminum industry one of the best examples. Because of the large amounts c power needed to reduce the oxide of aluminum to meta very low cost power is essential to produce the metal a reasonable cost. In the past the demands were met by th construction of hydroelectric plants, at first by privat enterprise, and more recently by government agencie However, the unprecedented demands for aluminum sinc World War II have resulted in power demands beyond th

acity of existing hydroelectric systems to supply all the uirements.

n an effort to supplement its power generating facilities l thereby increase its aluminum producing ability, the minum Company of America has just finished the con-iction of a plant at Point Comfort, Tex., which embodies umber of novel features. Located on the Gulf of Mexico out 110 miles southwest of Houston, the Point Comfort nt has access to large quantities of natural gas at reason-e cost. To furnish the demands of the adjacent reduc-n works, 120 gas engine generators of new design have n installed in the engine rooms. These units furnish ect current at suitable voltage to the pot lines, doing ay with the need for the conversion equipment normally uired when a-c power supply is employed.

The engine generators are housed in three engine rooms, h containing 40 units arranged in two rows of 20 each. ure 7 gives a good view of one engine room showing arly the horizontal radial type engines, each with its n automatic control panel nearby. Rated 1,600 horse-wer at 360 rpm, the engines are 2-cycle, 11 cylinders, d can be adapted with slight modification to gas, Diesel l, or dual fuel operation. Thermal efficiencies are ted to be approximately 30 per cent.[12] Basically, the dial engine design is said to result in a simple, compact, d sturdy arrangement, light weight, minimum founda-ns, and small floor space. This engine with its welded se is a little over 12 feet wide, 9 feet 4 inches high, ighs about 85,000 pounds, and can be shipped by rail as assembled unit.[13]

Two noteworthy design features of this radial gas engine ll be mentioned. In most radial engines, master con-cting rods are necessary to prevent rotation of the crank n bearing. The same result is obtained in the new engine an ingenious arrangement of gears so that all connecting ds are identical and are connected to a master gear which rates instead of rotating. A new ignition system was signed which is expected to operate for long periods of ne without attention or maintenance, and also to insure very low rate of spark plug electrode erosion. Ignition ergy is supplied by a special impulse generator supplying curately timed, unidirectional impulses. No cams, cuit-breaker points, brushes, collector rings, or rotor ndings are involved in this generator.

The d-c generators in the Point Comfort installation are ounted beneath the engines and coupled directly to them. net capacity of 1,150 kw is realized from each unit with gine auxiliaries motor-driven from auxiliary a-c windings the generators furnishing 425 volts at 24 cycles. An cellent view of a generator showing its accessibility for intenance is given in Figure 8.

Space will not permit any more detailed description of s interesting power plant which is the largest of its kind the world. Operating data on the new engines are not available although it is known that they have been per-ming satisfactorily to date. However, from the in-mation which has been published, it is clear that in this nt its designers expected to utilize low-cost fuel efficiently thout incurring transmission or conversion losses, and to ure lower first costs as well as greatly reduced mainte-nance costs through the compact, simplified design of the engine-generators. Of course, the power for the reduction plant might have been secured in other ways, as from a steam-generating plant, or by purchase. As more in-formation becomes public, it will be instructive to compare the costs for this gas engine-generator plant against the conventional power sources.

Other than the example given here, no outstanding applications of internal combustion engines for industrial power generation have been found. While the Diesel engine inherently has a good thermal efficiency, the high first cost of the units, the relatively high cost of Diesel fuel, and the operating labor and maintenance costs, together with the difficulty of obtaining any substantial heat re-covery from the exhaust gases, seem to make the Diesel engine unattractive to industries except, perhaps, as a stand-by source of power.

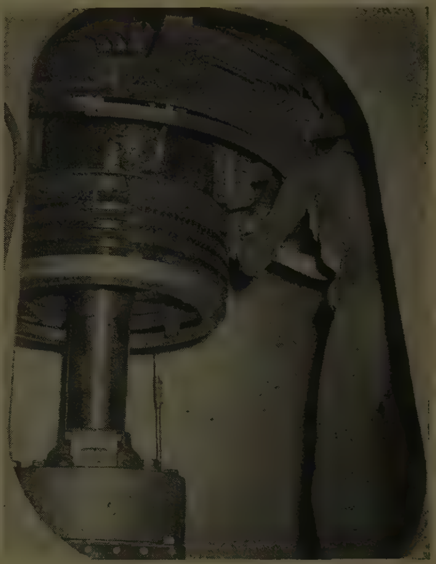


Figure 8. 1,100-kw d-c generator at the Aluminum Company's Point Comfort plant

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Series Capacitors in Long Transmission Lines

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ONE OF THE most important applications of series capacitors in long-distance transmission is to increase power capability to the economic maximum. This involves an increase in transient as well as steady-state stability of the transmission facility.

Since the capacitors are series-connected in the transmission circuit, with normal line-to-ground insulation, their internal reactance drop is proportional to the current transmitted. To effect best economy, the capacitors must be so designed in order that maximum desired or rated line current gives rated voltage drop across the capacitor assembly.

Under fault conditions, either on the compensated circuit or on adjacent interconnected circuits, the capacitor current may rise to several times rated value with resulting high overvoltage on the capacitors. Protection then must be afforded by short-circuiting or by-passing the capacitors for the duration of the fault with provision for restoring them to service after the fault has been isolated. If the fault is either on an adjacent circuit, or on the compensated circuit with high-speed reclosing, maximum stabilizing benefits of compensation can be realized only by restoring the capacitor to service with a minimum of time delay. The optimum benefit can be obtained only by restoring the capacitor to service within one-half cycle after fault isolation if on an adjacent circuit or if the capacitor is common to two or more circuits; in the case of high-speed reclosing on a single compensated circuit, the capacitor must be restored to service as soon as the line itself is restored.

It has not been possible to meet these conditions by the usual short-circuiting spark gap and contactor or circuit-breaker arrangement and a new approach has been made. A spark gap set at a safe overvoltage for short-time applications can provide protection against sudden overload and if this gap can be cleared by any process, such as by air blast, within one-half cycle of the time the current drops below the value producing initial spark-over, the capacitors will be restored to their original effectiveness.

In the first series-capacitor equipment to be installed in a 230-kv circuit of the Bonneville Power Administration, provision was made for high-speed restoration of capacitors following fault removal by employing a specialized type of air-blast gap, which is described fully in a companion paper.[1]

Careful analysis of system-operating conditions, together with the transient overvoltage capability of standard capacitors, indicated a required and permissible protective-gap setting of 2.5 times normal rated capacitor voltage. This value is within the short-time withstand capability of capaci tors and is necessary to prevent gap reignition after circui reclosure during the maximum stable swing of the system The primary protective device thus provided operates a 2.5 times normal rated voltage and restores the capacitor t service within one-half cycle of the time the current drop appreciably below 2.5 times normal.

Protection was provided against sustained overloads c values less than that required to flash the primary protectiv gap by an inverse-time overload relay controlling an over-al spring-loaded by-pass switch and co-ordinated with th time-overvoltage withstand ability of the capacitors. Thi switch operates if the fault on the line persists and curren through the gap lasts for more than 30 cycles; or if fo some prolonged time the line current is above the rate current of the capacitor installation so that the voltag drop across the capacitors is higher than their rated volt age but not high enough for flashover.

Overvoltage backup protection is provided by a simpl rod gap set at approximately three times rated capacito voltage and arranged to short-circuit the complete bank i each phase, if for any reason the main protective equipmen should fail to function. This gap is not self-clearing but i so connected that its operation will initiate the closing of th spring-loaded over-all by-pass switch.

In the present installation compressed air for the servic protective gaps is delivered to the insulated platforms carry ing the capacitors and their protective equipment throug insulating pressure columns from a compressor installatio on the ground outside the protective enclosure. A positio indication for the by-pass switch also is transmitted by ai through these columns.

No lightning arresters were considered necessary in thi installation inasmuch as overvoltages across the capacitor are controlled by the normal protective gaps. Groun wires are provided over this installation, which is adjacen to a substation containing transformers and other equip ment.

However, to prevent possible flashover to ground c the supporting insulator columns in the event of lightnin strokes beyond the ground wire area at times when the lin circuit breaker might be open, rod-gap protection was pr vided on the line side of the capacitor to ground. This ro gap is co-ordinated with the station lightning arresters an should not flash except under extraordinary conditions c possibly with the line circuit breakers open.

As reported in a companion paper, tests have shown th the equipment performs essentially in accord with spec fications and that relay protection of the system in general not affected materially by such an installation.

Digest of paper 51-303, "Functional Requirements of Series Capacitors in Long Distance Transmission Lines and a Description of Fundamental Features of the Installation in the Bonneville Power Administration System," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, Portland, Oreg., August 20–23, 1951. Not scheduled for publication in AIEE *Transactions*.

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Tensorial Analysis of Transmission Systems

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A METHOD OF ANALYSIS is outlined to solve steady-state problems arising in the operation of ge interconnected transmission systems exchanging wer between their own operating divisions and outside npanies. Special attention is paid to the calculation of al and incremental losses between the various sub-iary and outside companies. This first part restricts elf to laying the necessary foundations for the numerical dy made in a companion paper[1] on the system of the nerican Gas and Electric Company, New York, N. Y.

The pioneering work in placing the study of economic ding of transmission systems on a more rational basis due to E. E. George.[2] The use of the a-c analyzer in nnection with studies has been pioneered by Ward, ton, and Hale who also extended the concepts of George d placed them on an analytical foundation.[3]

Their contributions, however, bring into sharper focus e inadequacy of present-day methods of thinking to cope th the large-scale analytical needs of the power-system gineer. Although their assumptions about the operating havior of a single system are about the simplest possible, vertheless the amount of measurements involved and the nount of numerical calculations needed grow to pro-bitive proportions with the size of present-day systems.

A far more serious objection to the use of conventional ethods is their inflexibility. For instance, both the total s formula and the method of measurements are valid ly for the limited assumptions mentioned. If the gineer attempts to add one more assumption, the whole s formula collapses and so does the suggested method of easurement. For every added assumption the engineer forced to start from scratch to develop an entirely new s formula and a new procedure of measurements.

There seems to be no question that the solution of the oblems of modern interconnected transmission systems quire an analytical tool possessing the speed, versatility, d range of an airplane rather than those of an old-hioned horse and buggy.

The purpose of the present article is to introduce a new ethod of thinking to attack vigorously the problems sing in the everyday operation of integrated power tems having several divisions that exchange powers nong each other and with outside operating companies.

The following extensions and generalizations already rformed may be mentioned as illustrations for the power d possibilities of the new method of thinking:

1. The concepts of hypothetical loads, generators, and etering points are introduced that replace the large number of actual loads, generators, or metering points by a small number, or by one only.

2. Instead of assuming that the ratio of the load currents remains constant as the generator powers vary, it has been assumed that the ratio of the real components of the load currents remain constant and also the ratio of their reactive components.

3. Instead of assuming that the generator and load terminal voltages vary merely to satisfy the impedance-drop requirements of the current changes, it has been assumed that, as the loads vary, all generators and loads swing in angle so that the absolute value of their terminal voltage remains constant; or assumes preassigned values.

The system to be analyzed may consist of several operating divisions with different types of loads, each division supplying power to the others and to outside companies. The following problems arising in their operation have already been solved, in addition to those mentioned:

1. Calculation of the resultant interchange power transferred between the divisions, between outside companies, or between the divisions and outside companies.

2. Determination of the I^2R and I^2X losses incurred in the territory of a division due to a transfer of power across its lines between any other two divisions or outside companies.

3. Determination of the I^2R and I^2X losses incurred due to the utilization of only a limited group of generators to transfer power to outside companies.

4. Determination of losses due to power circulating between two neighboring divisions and to power sneaking around several divisions tied together into a closed mesh.

Problems relating to interchange power and those relating to the charging for losses incurred in transmitting power through the lines of other companies are often independent of economic loading considerations and need be solved as such. In attacking any of these problems it has been necessary to introduce some or all of the following additional complications:

1. Autotransformers exist in the system whose turn-ratio currents must also be considered.

2. Large charging currents exist that cannot be lumped together with the loads but must be considered as independent variables.

3. The synchronous condensers are treated not as loads but as generators of purely reactive power.

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An Unattended Broad-band Microwave Repeater for the TD-2 Radio Relay System

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To meet the stringent requirements of the 4,000-mile transcontinental microwave relay system, a number of new developments had to be included in the design of the repeater stations. The circuits of these unattended stations, and how they are maintained, are the subject of this article.

THE MICROWAVE REPEATER of the *TD-2* transcontinental relay system, while similar in principle to that of its predecessor in the New York-Boston system,[1] incorporates recent developments which enable it to meet the design objectives of a 4,000-mile long-haul radio relay system. The development of the Western Electric *416A* close-spaced triode[2,3] has made possible the design of a more efficient, wider bandwidth microwave repeater having improved transmission characteristics. The operation of this repeater from 12-volt and 250-volt batteries insures greater reliability of service. The development of new types of waveguide filters and channel separation networks[4] permits six broad-band radio channels to be multipled on one transmitting or one receiving antenna.

REPEATER DESCRIPTION

A BLOCK DIAGRAM of a 1-way repeater is shown in Figure 1. Ideally, the repeater is simply a wide-band amplifier flat to within 0.2 decibel over a 20-megacycle band, with variable gain sufficient to compensate for the path loss between stations plus an adequate fading margin. In the *TD-2* system the incoming microwave signal is converted to an intermediate-frequency band at 70 megacycles where about 75 per cent of the required gain is provided.

The composite incoming microwave signals for as many as six broad-band channels are received in the delay lens antenna at the top of the tower and brought down to the repeater room through waveguide. The desired channel is selected by a particular channel separation network and combined in a balanced silicon-crystal converter with a quartz-crystal controlled beating oscillator source to provide an intermediate-frequency signal band centered at 70 megacycles. The signal is amplified in a low-noise intermediate-frequency preamplifier and a higher gain intermediate-frequency main amplifier which employs automatic gain control to compensate for atmospheric fading and the gradual aging of the repeater tubes. The intermediate-frequency signal then is combined in the transmitter modulator with another crystal-controlled beating oscillator source to provide a microwave signal band offset 40 megacycles from the incoming signal. This 40-megacycle shift in receiving and transmitting frequencies reduces the effect of crosstalk between the transmitting and receiving antennas. The desired modulation side band is selected by waveguide filters in the trans mitter modulator and amplified in a microwave amplifie to give an output power of 0.5 watt. The output of th microwave amplifier is combined in the transmittin channel network for transmission through waveguide t the transmitting antenn which is directed toward the next station some 30 mile away.

The beating oscillato source for the transmittin modulator consists of a quartz crystal controlled oscillato followed by six stages of har monic generators. A succes sion of doublers and tripler (three of each) are used to multiply a crystal frequency o about 18 megacycles 216 times to supply the required 20 milliwatts of power at the microwave frequency. A por tion of this output is combined in a 40-megacycle shifte converter with the output from a crystal controlled 40 megacycle generator and the proper side band selected t supply the few milliwatts of beating oscillator power re quired for the receiving converter.

This arrangement provides the 40-megacycle shift be tween the received and transmitted frequencies and sinc a common beating oscillator source is used for both th receiver converter and the transmitter modulator, th transmitted output frequency is unaffected by frequenc deviations of the microwave generator. As a result th only cumulative frequency errors in the auxiliary re peaters of a long-haul system are caused by small erro in the crystal-controlled 40-megacycle generator. How ever, at main stations this feature cannot be used since eac radio section between main stations must be independe of other sections for switching, branching, maintenanc and terminating purposes. Separate microwave generato therefore are used to supply the beating oscillator fr quencies for the radio receivers and the radio transmitte at main stations. Only a few milliwatts of beating osci lator power are required for a receiver converter so it possible to eliminate the penultimate stage of the micr wave generator and use the last stage as a sextupler. Th frequency stability requirements at main stations a more severe because any possible errors add througho a long system. The crystals in these microwave generato

Essential text of a conference paper, "An Unattended Broad-band Microwave Repea for the TD-2 Radio Relay System," presented at the AIEE Summer General Meeti Toronto, Ontario, Canada, June 25–29, 1951.

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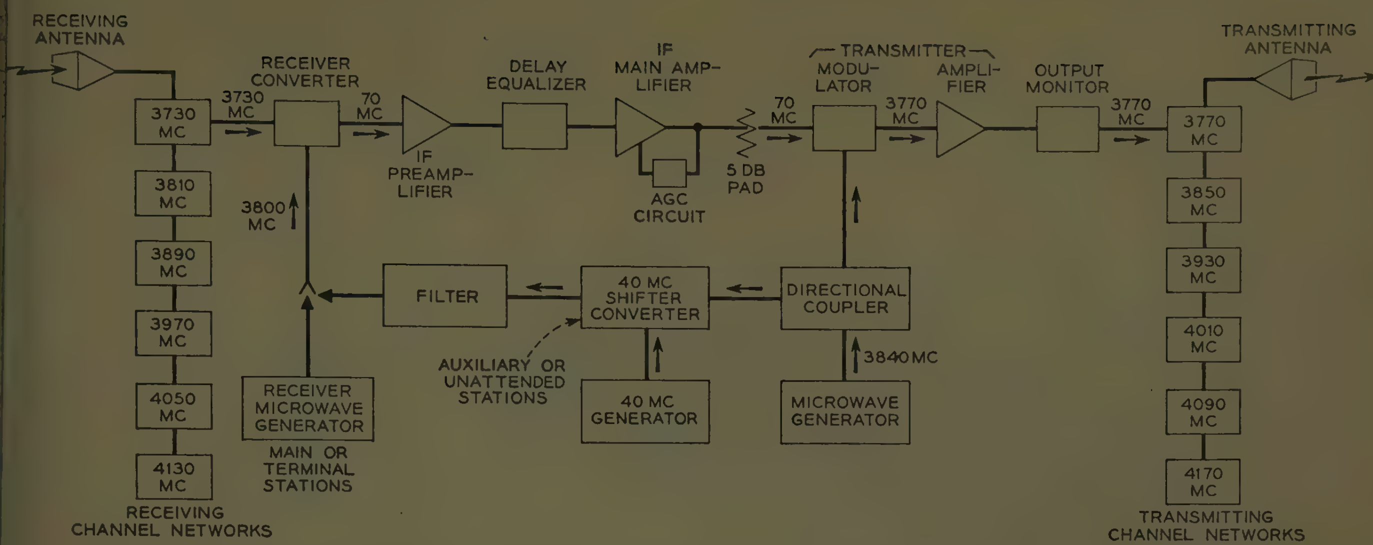


Figure 1. Block diagram of a 1-way TD-2 repeater. Ideally the repeater is a 20-megacycle band-pass amplifier with enough gain to make up for signal loss between stations

re therefore temperature-controlled and are checked egularly.

Figure 2 is a front view of a typical main station repeater ay. The signals enter and leave through the channel eparation networks at the top of the 9-foot frame. The ncoming signal passes through the image suppression ilter, receiver converter, intermediate-frequency pre-mplifier, and intermediate-frequency main amplifier n the left side of the bay. The transmitter modulator nd transmitter amplifier are on the right. The lower alf of the bay contains the receiver and transmitter ontrol units, and two microwave generators in the case f a main station repeater bay. At an auxiliary repeater tation the receiver microwave generator is replaced by a 0-megacycle shifter unit. The receiver control unit ontrols the application and metering of power to the eceiver portion of the bay and supplies automatic-gain-ontrol voltage to the intermediate-frequency main ampli-ier. The transmitter control unit controls the application nd metering of power to the transmitter modulator and mplifier.

The repeater bay is designed for single-side maintenance vith all equipment accessible and removable from the ront. In a typical office any number of repeater bays p to six are lined up side-by-side with their channel eparation networks progressively increasing in frequency n steps of 80 megacycles. Repeater bays can be mounted ack-to-back or in an opposing line-up to provide six hannels in the opposite direction of transmission. This rocedure facilitates the growth of these systems as addi-ional bays can be added to the line-up with a minimum of own-time for installation. Plugs and jacks are used for adio-frequency and power interconnections to facilitate naintenance. Quick-release clamps are used wherever he waveguide components are to be separated for test.

RECEIVER COMPONENTS

FIGURE 3 SHOWS one of the typical channel separation networks[5] which separate the desired channel from he other incoming signals for amplification in a particular repeater. It consists of two hybrid junctions and two band-reflection filters which are tuned to the desired signal band. An incoming signal divides equally in the input hybrid into parallel paths through the band reflection filters.

These filters are transparent to signals located outside the band to which they are tuned and such signals are accordingly combined in phase in the output hybrid for transmittal to the channel separation networks in the adjoining bays. Signals in the desired band, however,

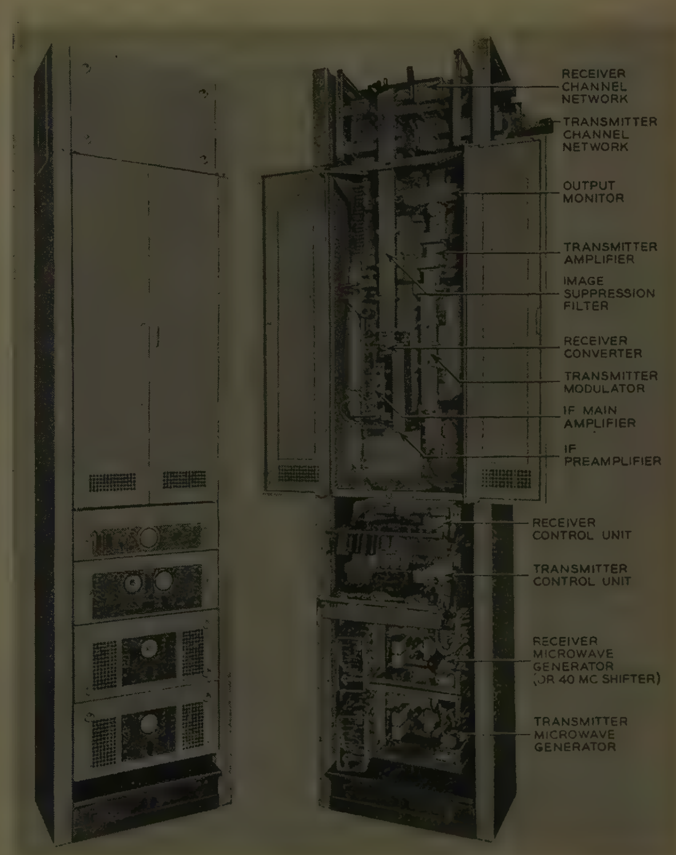


Figure 2. The TD-2 repeater bay, showing layout of components

are reflected back to the hybrid. The electrical path length from the hybrid to each of the band-reflection filters differs by a quarter wavelength so that their reflected signals are in phase opposition at the hybrid. This is the condition which results in all of the power being transmitted to the output arm of the hybrid and thus through the image suppression filter to the receiver converter.

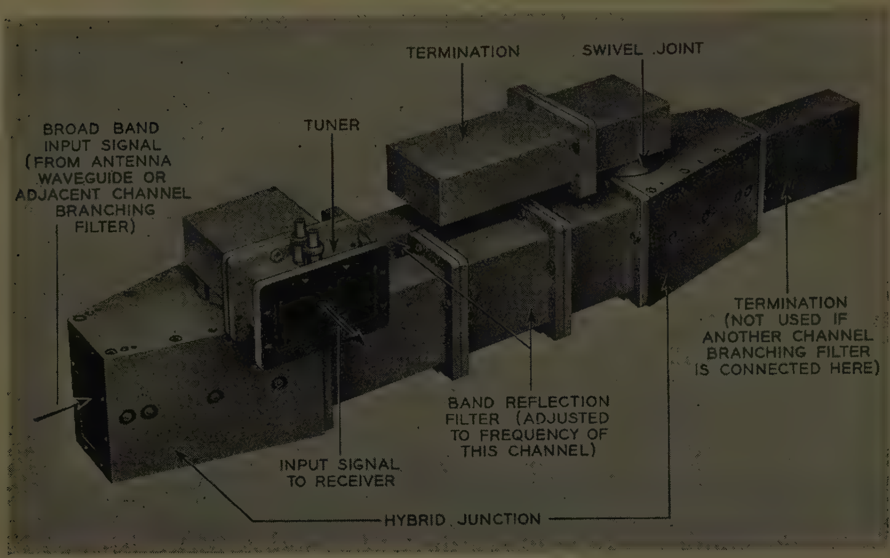


Figure 3. The channel separation network used in the repeater

An image-suppression filter provides discrimination against interfering signals 140 megacycles removed from the desired incoming signal, attenuates any extraneous beating oscillator frequencies which might leak through the channel separation networks into adjacent channels, and provides a means of reflecting the proper impedance to the converter at the image frequency for the purpose of controlling the converter intermediate-frequency output impedance.

The receiver converter and intermediate-frequency preamplifier illustrated in Figure 4 consists of a balanced silicon-crystal converter and a 2-stage grounded-grid 70-megacycle intermediate-frequency preamplifier. The *405A* varistor was developed for this application. It is similar to the *IN23* crystal rectifier but has a symmetrical terminal design. The double ended varistors are matched into the hybrid junction in opposite polarity so that their intermediate-frequency in-phase outputs can be connected in parallel directly to the cathode of the first grounded-grid amplifier. This eliminates a critical balanced-to-unbalanced intermediate-frequency transformer. The beating oscillator is brought into the junction of the two varistors through a coaxial transformer whose input connection can be seen at the top of the converter. A waveguide impedance matching section is used ahead of the receiver converter to improve the impedance characteristic presented to the image-suppression filter. The return loss ($20\log_{10}$ transmitted power/reflected power) is 30 decibels or more over a 20-megacycle signal band. (Voltage standing wave ratio=1.06.) The converter balance is 25 decibels or more.

The intermediate-frequency preamplifier consists of two grounded-grid *417A* triodes in tandem which give about 12 decibels gain. The transmission band is centered at 70 megacycles and is flat to within 0.1 decibel over a 22-megacycle band. The noise figure for the converter and intermediate-frequency preamplifier as maintained in the field is about 13 to 17 decibels. The net gain of the converter and intermediate-frequency preamplifier is about 6 decibels. The 75-ohm coaxial output of the intermediate-frequency preamplifier is patched through an envelope delay distortion equalizer to the input of the intermediate-frequency main amplifier.

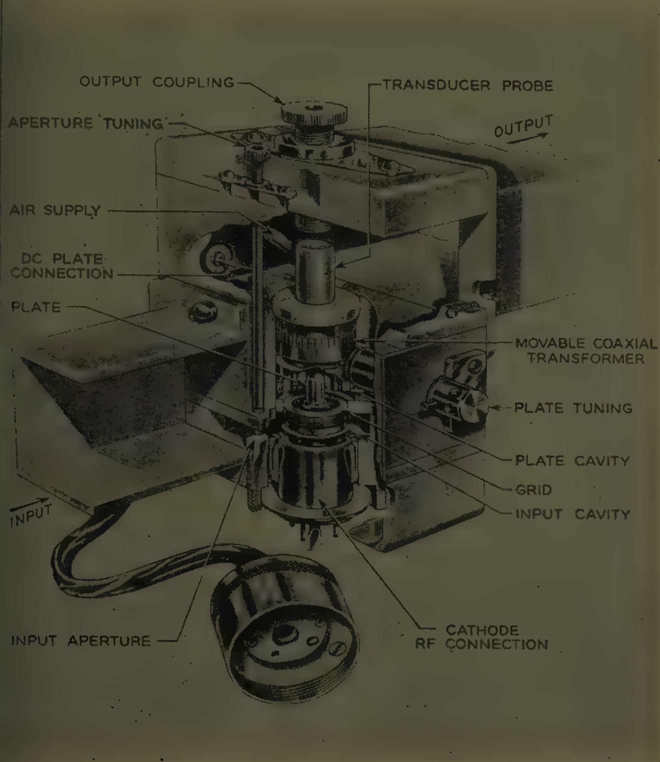
The 8-stage intermediate-frequency main amplifier provides about 65 decibels of the approximately 90-decibel gain possible in the repeater. The transmission band is centered at 70 megacycles and is flat to within 0.1 decibel over a 20-megacycle band. A *417A* triode is used in a conventional grounded-grid circuit in the first stage followed by six stages of *404A* high transconductance pentodes and a *418A* tetrode output stage. The input, interstage, and output networks are all of the double-tuned impedance-matched type except the network between the sixth *404A* pentode and the *418A* output tetrode. This network is triple-tuned and mismatched and provides for adjustment of the over-all transmission-band shape. A portion of the output of the intermediate-frequency main amplifier is rectified and a d-c bias voltage derived in the

Figure 4. The receiver converter and intermediate-frequency preamplifier

receiver control unit for automatic gain control purposes. Automatic-gain-control operating upon the grids of the first five *404A* pentode stages maintains the output power to within 1 decibel for upward fades of 5 decibels and downward fades of 25 decibels below the free space value. Local feedback is used in the biasing of the first stage and

e last two stages to keep the plate current, and hence e gain, more nearly constant from tube to tube, and ver the life of the tubes.

The majority of the tubes in the repeater are operated ith their heaters fed by series dropping resistors from a



igure 5. Cutaway view of the 416A triode in an amplifier cavity

losely regulated 12-volt battery, thus approximating the onstant power heater conditions favorable to increased ube life and reliability. Routine filament activity tests re made on many of the tubes in the repeater as an aid n forecasting when they should be eplaced. This test consists of noting the effect on plate current or ransconductance of a specified reluction in heater voltage on the ube under test. Intermediate-frequency components generally are lesigned to have a 75-ohm input and utput impedance which facilitates heir test and interconnection using ow standing-wave-ratio plugs, jacks, nd coaxial cable.

The output from the intermeliate-frequency main amplifier is atched through a 5-decibel pad nto the 70-megacycle input of the ransmitter modulator, when the ay is used as a repeater at auxilary stations. At main stations the eceiver output is patched through 6-decibel pad to the intermediate-requency patching and monitoring bay which provides the flexibility for the changing requirements of network distribution. Conversely, the signal from the intermediate-frequency patching bay at main stations is patched through a single-stage *418A* intermediate-frequency buffer amplifier into the intermediate-frequency input of the transmitter modulator. The 5-decibel pad at auxiliary stations and the intermediate-frequency buffer amplifier with its associated pad at main stations are used to improve the intermediate-frequency input impedance characteristic of the transmitter modulator and minimize the effects of long cables in the intermediate-frequency patching circuits.

TRANSMITTER COMPONENTS

The use of a *416A* close-spaced triode as a modulator provides a conversion gain of about 9 decibels in shifting the intermediate-frequency signal to the desired channel in the 3,700- to 4,200-megacycle common carrier band. The transmission band of the modulator is flat to within 0.2 decibel over a 20-megacycle band. Figure 5 shows a cutaway view of a typical microwave amplifier and transmitter modulator cavity with the *416A* grounded-grid triode screwed into place. The input cavity is formed between the cathode and the grid, and is coupled to the input waveguide by means of an iris or aperture which is tuned by a capacitive screw. The cathode of the tube is internally by-passed to the cathode shell which, in turn, is grounded by the cathode springs. A coaxial cavity is formed between plate and grid which is tuned to the desired frequency by varying the position of the quarter-wave coaxial transformer that matches the triode into the waveguide. A capacitive loading screw aids in matching the coaxial to waveguide transducer.

The transmitter modulator is shown in Figure 6. The beating oscillator power is coupled to the modulator input cavity through a coaxial to waveguide transducer, a band rejection filter, an impedance matching section, a beating oscillator band-pass filter, and a waveguide spacer. The

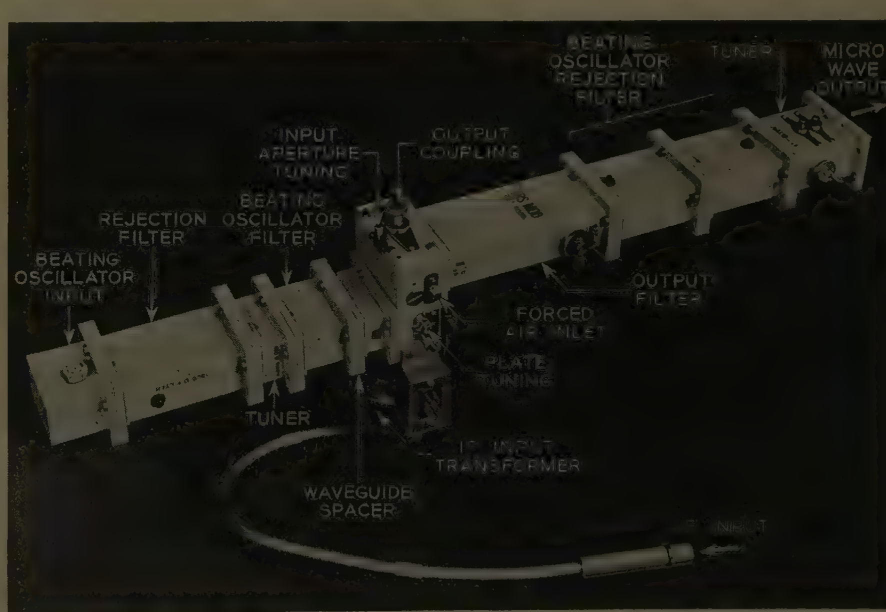


Figure 6. The transmitter modulator as used in the repeater, showing how the various sections are fitted together

intermediate-frequency input signal is coupled directly to the cathode of the *416A* modulator by means of an impedance transforming network contained in the cylindrical shield enclosing the tube socket. The desired output side band of the modulator is selected in a 2-section resonant-iris band-pass filter coupled to the output cavity. Additional band rejection filters are used to attenuate the beating oscillator frequency and other undesired modulation products. A waveguide impedance-matching section is used to improve the impedance presented to the microwave amplifier over the signal band.

The microwave amplifier shown in Figure 7 is a 3-stage *416A* grounded-grid amplifier capable of 17 decibels gain and a power output of 0.5 watt. Each amplifier cavity is similar to the cutaway view shown in Figure 5. The cathode connections in the amplifier cavities, however, are by-passed directly to ground. The three stages are connected together in tandem through waveguide spacers and impedance-matching sections of such dimensions that the joining of each output cavity with the following input cavity (or resonant iris filter section in the case of the output stage) forms a double-tuned critically coupled transformer. The transmission characteristic of the amplifier is flat to within 0.1 decibel over a 20-megacycle band. The input impedance return loss is 17 decibels or more (1.33 voltage standing wave ratio) and the output impedance return loss is 24 decibels or more (1.14 voltage standing wave ratio) over a 20-megacycle band. The plate current of the last stage is held at 30 milliamperes at 200 volts and the other two stages are adjusted to lower values of plate current that will limit the over-all gain to 17 decibels. Each *416A* tube cavity is cooled by approximately 0.1 cubic foot per minute of air at a pressure of 5 inches of water.

The output of the transmitter amplifier is connected through a directional coupler to the outgoing channel combining networks at the top of the bay. One branch

Figure 7. A 3-stage 416A grounded-grid microwave amplifier

of the directional coupler having a 25-decibel loss is used in conjunction with mobile test equipment for over-all transmission tests on the repeater bay. The other 25-decibel branch of the directional coupler and its associated crystal monitor are used to read directly the approximate power output of the repeater and transmit an alarm in the event of a 10-decibel drop in output power. The channel combining networks are similar to the channel separation networks described earlier.

REPEATER MAINTENANCE

A MOBILE TEST BAY is provided at all auxiliary, main, and terminal stations to facilitate routine preventive maintenance, isolation of troubles, and realignment of the

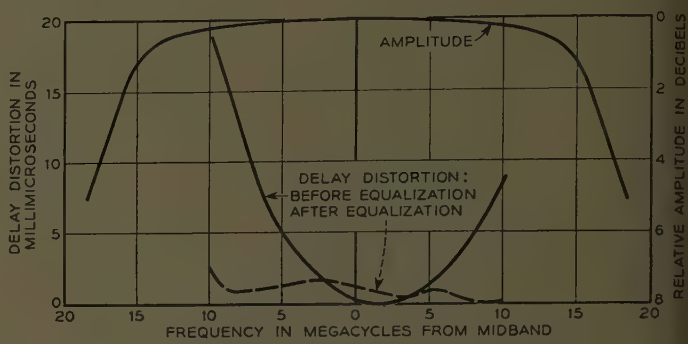


Figure 8. Repeater amplitude and envelope delay distortion characteristics

repeater bay after installation of spare components. The majority of *TD-2* stations are unattended auxiliary stations and the test bay for these contains a microwave sweeping oscillator, an oscilloscope, a combined microwave and intermediate-frequency power meter, radio-frequency and intermediate-frequency attenuators, frequency meters, detectors, and associated power supplies. The test bay for maintenance centers and main and terminal stations also contains an intermediate-frequency sweeping oscillator covering the 50- to 90-megacycle range and additional intermediate-frequency attenuators to permit extensive tests of the intermediate-frequency components.

This test equipment can be used for single-frequency measurements at known power levels or for over-all swept frequency tests. Each repeater bay is adjusted to provide a transmission band of 20 megacycles, flat to within 0.2 decibel and centered at the assigned channel frequency. The individual transmitter and receiver units described here are held to about the same limits, so trimming adjustments are provided on some of these units to obtain this over-all repeater characteristic. The swept signal in such a test is divided into a reference path and a path through the equipment under test, each of which is terminated in an identical detector. The outputs of these detectors are alternately applied to the vertical deflection amplifier of the oscilloscope at a 30-cycle rate, while a voltage proportional to the frequency excursion is applied to the horizontal deflection amplifier. Generally, the vertical gain of the oscilloscope is adjusted so that a separation of 1 inch between the test and reference traces corresponds to a level difference of 1 decibel and the horizontal gain is adjusted so that 1 inch corresponds to a 10-megacycle frequency excursion. The test trace then is matched to the reference trace by adjustments of the equipment under test.

Maintenance centers usually are operated by the same

staff that maintains the repeater stations in the route section. The maintenance center test facilities include, in addition to the test bay, a test bench for accurate impedance-match measurements at radio and intermediate frequencies, for varistor matching tests, and for general component tests which cannot be made at the repeater station. A portable frequency calibrator is used for checking the calibration of microwave generators, 40-megacycle generators, and all frequency meters used in the system.

REPEATER DELAY CHARACTERISTICS

FIGURE 8 SHOWS the amplitude and envelope delay distortion characteristics for a typical repeater. The amplitude characteristic is maintained flat to within 0.2 decibel over a 20-megacycle band. The envelope delay distortion without equalization increases from zero at midband to as much as 20 millimicroseconds at the edges of the 20-megacycle band. The cumulative effect of over a hundred unequalized repeater and terminal stations in a transcontinental system would be intolerable for message service so an intermediate-frequency envelope delay distortion equalizer is inserted in each repeater between the intermediate-frequency preamplifier and intermediate-frequency main amplifier. The dotted curve shows the effect of this equalizer in reducing the delay distortion over the band. The use of mop-up equalization and greater stabilization of delay characteristics promises a marked increase in the future in the number of transcontinental message circuits possible with this new type of communication facility.

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New Single-Phase 4-Motor Equipments for A-C Multiple-Unit Transit Cars

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Promising appreciable savings in maintenance costs, this equipment has some features new to a-c rapid-transit car design. A truck-mounted motor drives each axle and a cam-operated controller operates the resistance acceleration.

A NEW TYPE of 25-cycle a-c multiple-unit rapid-transit car equipment, using a truck-mounted motor driving each axle and a resistance acceleration scheme operated by a new motor-driven cam controller, has been developed. This new equipment may lead to the development of dynamic braking on a-c cars of this type. Equipment parts are lighter, smaller, and less expensive.

New to a-c car design, motor capacity is distributed over all four axles, and motors are truck mounted instead of axle-hung, providing better riding qualities and reducing wear on motor and truck parts. Self-contained gear units are semipermanently axle-mounted in roller bearings to eliminate friction bearings and misalignment troubles. Motors and gear units are dismounted independently of each other to reduce maintenance time. The weight of the four traction motors complete with gear cases, pinions, gears, and couplings is less than that of any a-c 2-motored equipment which has been built for the same service in this country.

The new motor is a low-flux 6-pole 25-cycle single-phase series motor with commutating and compensating windings. Light weight is achieved by making the maximum operating speed 3,900 rpm, corresponding to a road speed of 90 miles per hour with 36-inch wheels and a 128/28 gear ratio. The commutator is arch-bound, using ring-nut construction, and has been proportioned for low stresses. The armature core is 14 inches in diameter, and is wound with single-piece preinsulated coils. The 680-pound armature is mounted on a 60-millimeter ball bearing at the commutator end, and a 70-millimeter roller bearing at the drive end. These bearings carry very little load

Condensation of three technical papers: **51-35**, "Why Four-Motor Multiple-Unit Car Equipments?" by R. A. Williamson; **51-106**, "A-C Multiple-Unit Car Motor," by F. C. Kreitler, Jr.; and **51-107**, "A-C Multiple-Unit Car Control Equipment," by W. S. O'Kelly, recommended by the AIEE Committee on Land Transportation.

The original papers were approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

R. A. Williamson, F. C. Kreitler, Jr., and W. S. O'Kelly are all with the General Electric Company, Erie, Pa.

Figure 1. The new low-flux 25-cycle single-phase series motor

other than the weight of the armature. Figure 1 shows the motor.

Stator windings are made of preinsulated conductors, and because winding slots do not have overhanging tooth tips, the compensating coils are completely insulated before assembly. The motor is self-ventilated, eliminating the need for separate blowers and air ducts.

Each motor is supported by, and overhung from, the truck transom with a key and five bolts. The motor is removed, when the truck is out from under the car, by unbolting the coupling and removing the five bolts. The motor then is lifted easily from the truck. An arrangement of rubber bushings positions the motor so that only 7 per cent of the 50-cycle torque pulsation is transmitted to the truck.

The motor drives the axle through a separate gear reduction unit, using helical gearing, with a flexible coupling between motor and gear unit. The pinion is carried on tapered roller bearings, and the gear unit is mounted on the axle with similar bearings to take the thrust of the helical gearing. A flexible coupling in the gear shaft joins the truck-mounted motor to the gear unit. A soft rubber insert around the internal gear of the spherical-gear type coupling absorbs approximately 95 per cent of the 50-cycle torque pulsation of the armature.

The new heavy-current, cam-operated control, shown in Figure 2, is similar to that used on 600-volt d-c subway cars and d-c multiple-unit railroad cars, and is radically different from previous a-c car controls. Resistance is used for acceleration instead of the conventional transformer taps. Resistor loss is reduced by changing the voltage applied to the motors after the controller has run through resistance in one direction, instead of changing the motor connections. The compact controller replaces all but two of the electropneumatic tap switches on older equipments. It provides mechanical interlocking of the sequence, improves reliability, and reduces risk of damage from malfunctioning. Cam-closing torque peaks of the mechanism are reduced to practical values by using both opening and closing cams and overlapping contacts. This is the first time a compact, direct-operating power controller, with a capacity of 1,350 amperes continuous and driven by a small d-c motor, has been developed for this type application.

The askarel-filled-type main power transformer is hung from the center sill of the car. Its secondary winding has only three terminals, providing 240 volts and 385 volts as required by the motors.

Primary protection is provided by a pantograph grounding switch, tripped by a thermal relay in case of lower order overloads or by instantaneous relay in case of higher current faults. Other protective devices include a Thyrite lightning arrester, transformer overheating thermostat, traction

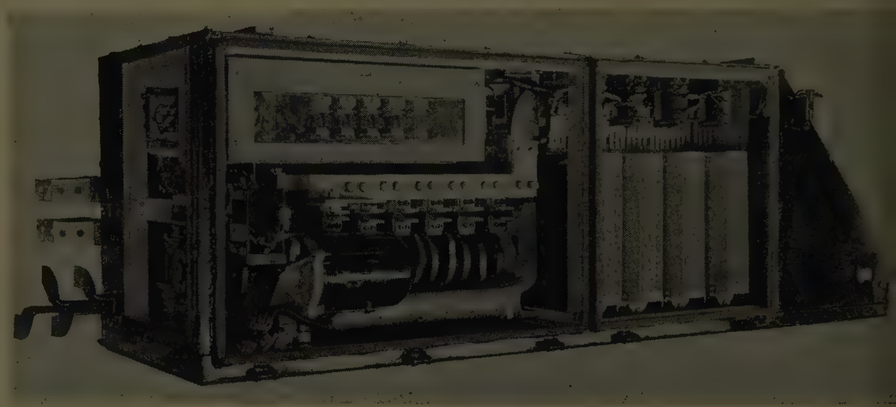

Figure 2. The main control group for the equipment arranged for undercar mounting

motor overload relays, and also ground detection relays.

The development of this 4-motor equipment promises a significant improvement in suburban railroad commuter service. Passengers want fast, comfortable, dependable, low-cost service: the railroads need equipment that will meet this demand as well as provide increased return on investment through greater usefulness and availability of equipment and save money by reduced maintenance and wear. Fast schedules in frequent-stop service require high accelerating and braking rates. At the same time reasonable high top speeds are needed for express and semiexpress runs, since large suburban operation is a composite of both.

Only modern equipment with every axle motored serves all these needs best. Furthermore, better advantage can be taken of technical progress in reducing the weight of cars and equipment. Such weight reductions would release motor capacity to produce extra performance without exceeding workable adhesion limits. This would be impossible with 2-motor equipment, whose performance is already limited by adhesion. The cost of such 4-motored equipment is no higher than that of 2-motor equipment if reasonable quantities are purchased.

Line-Drop Compensation on Single-Phase Regulators

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WHEN SINGLE-PHASE voltage regulators are connected in delta or in open-delta on 3-phase systems, the regulator is excited by the line-to-line voltage, but it transmits line current. For this reason, a line-drop compensator in the control circuit of a regulator so connected has a 30-degree phase difference between its voltage and current supplies. The proper operation of the regulator depends upon the line-drop compensator's duplicating, in the control circuit, the effect of resistance and reactance voltage drops in the line. To permit this, the effect of the 30-degree phase displacement between voltage and current must be counterbalanced.

One method of obtaining correct line-drop compensation is to interconnect the secondaries of the line-current transformers so that one line current is subtracted from another, and the difference current divided by $\sqrt{3}$ is applied to the line-drop compensator. For example, if $I_A=I\epsilon^{j0}$ and $I_B=I\epsilon^{-j120}$, then $(I_B-I_A)=\sqrt{3}I\epsilon^{j210}$. Thus (I_B-I_A) lags I_B by 30 degrees. An auxiliary current transformer is used to reduce $\sqrt{3}I$ to I.

For open-delta connections, using only two voltage regulators for 3-phase service, an auxiliary 3-winding current transformer having a turns ratio of 1.00/0.866/0.50 permits interconnecting the two line-current transformer secondaries to obtain correct line-drop compensation. This is possible because if $I_A=I\epsilon^{j0}$ and $I_C=I\epsilon^{j120}$, then $1.00I_A+0.50I_C=0.866I\epsilon^{j30}$.

A second method of obtaining correct line-drop compensation is to use a phase-shifting network. Such a network, consisting of resistors and reactors, usually is connected in the current transformer circuit. Taps provide a means of making the network either a normally balanced circuit giving zero phase shift, a highly reactive circuit advancing the phase angle by 30 degrees, or a highly resistive circuit retarding the phase angle by 30 degrees. The resistance, the reactance, and the details of connection required are quite critical and are usually an integral part of the line-drop compensator.

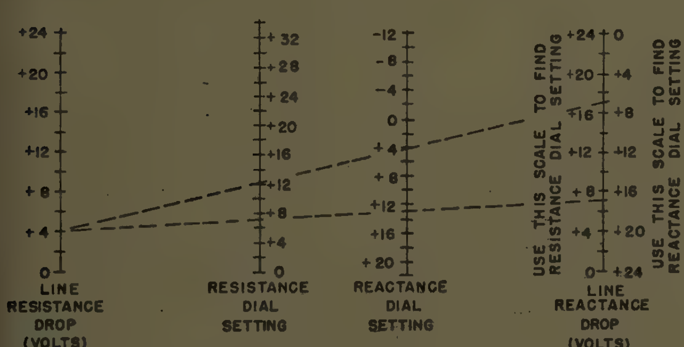

Figure 1. Wagner Chart for unit with leading current. Example: If line resistance drop is 4 volts and line reactance drop is 7 volts, set resistance dial on +7 and reactance dial on +4

Both methods which have been described shift the phase of the current by 30 degrees. The voltage drop in the line is the product of the current and the impedance. The same results may be obtained by shifting the impedance by 30 degrees, since

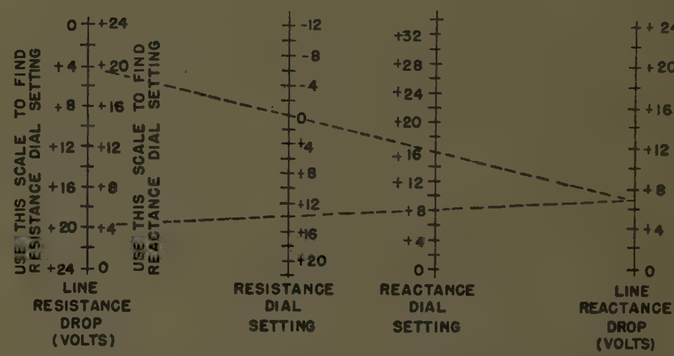

Figure 2. Wagner Chart for unit with lagging current

$$I\epsilon^{j(\theta+30)}\,Z\epsilon^{j\phi}=IZ\epsilon^{j(\theta+\phi+30)}$$

and

$$I\epsilon^{j\theta}\,Z\epsilon^{j(\phi+30)}=IZ\epsilon^{j(\theta+\phi+30)}$$

The third method of obtaining correct line-drop compensation is to modify the dial settings on the compensator to correspond to an impedance shifted by 30 degrees. If the actual line drop is $IZ\epsilon^{j(\theta+\phi)}$, and if the regulator is in delta or open-delta connection so that the current in the regulator is $I\epsilon^{j(\theta\pm30)}$, then the compensator dial is set for $Z\epsilon^{j(\phi\mp30)}$. If $Z=R+jx$, this becomes $(0.866R+0.5x)+j(0.866x-0.5R)$ for the unit with the current leading the voltage and $(0.866R-0.5x)+j(0.866x+0.5R)$ for the unit with the current lagging the voltage. For convenience, the mathematical expression is reduced to a set of two charts, called Wagner Charts, shown in Figures 1 and 2.

Each method has its advantages. Methods one and two do not reduce the range available on the line-drop compensator. Methods one and three do not require compensators designed for use with phase-shift networks. Methods two and three do not require control interconnections between units. The requirements of the application determine the method selected. All three methods are used and give satisfactory operation.

Digest of paper **51-300**, "Some Methods of Obtaining Correct Line Drop Compensation on Single Phase Voltage Regulators Used on Three Phase Systems," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, Portland, Oreg., August 20–23, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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DBPC Inhibited Oil in Semisealed Transformers

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WIDESPREAD INTEREST in 2,6 ditertiary butyl para cresol (DBPC) as an inhibitor for transformer oils has resulted in extensive usage, largely based on evaluation by laboratory means. Earlier studies reported in a paper by the authors[1] on long operation of small semisealed transformers indicated that evaluation in actual transformers was desirable and also that useful information might be obtained from accelerated operation.

With the purpose of rapid evaluation of this inhibitor as an initial additive to normal oils whose characteristics are well known, small transformers have been run with high oil temperatures and the relative performance of normal oil and the same oil with 0.3 per cent and 0.4 per cent DBPC added by weight has been gauged by the first appearance of sludge. While this is not necessarily a sound criterion, it may be used arbitrarily as a basis for determining the effectiveness of the inhibitor. It is believed that the comparison should be carried out through a more extended period and ultimately beyond the life of the inhibitor.

On the point of what constitutes life of oil there seems to be a wide diversity of opinion among operators. Presumably, this is based on cost considerations; that is, the amount of observation, maintenance, reclamation, or replacement which is considered justifiable under particular conditions. One extreme view is that no sludge should be permitted. This will require meticulous knowledge and very active maintenance or a reclamation program and will be based, of course, on the determination of the first appearance of sludge.

The other reasonable extreme might be that chosen in our earlier studies; that is, an amount of accumulated sludge (1 per cent) and acid (1 milligram potassium hydroxide neutralization) which has not yet affected the operating characteristics of the transformer, but which indicates the desirability of corrective action within a reasonable time.

Between these extremes, intermediate values of sludge and acid are chosen by individual operators, and there will probably continue to be some divergence of opinion.

With the purpose previously mentioned, three 5-kva semisealed transformers were run under load conditions at a fixed ambient temperature and were accelerated by the use of a high top-oil temperature (95 degrees centigrade) and continuous duty, without excluding oxygen. Conditions were such that coil temperatures were maintained at 105 degrees centigrade (average) with a 115-degree-centigrade hot spot. One transformer contained normal transformer oil and the other two, normal oil which had been inhibited by two different percentages of the DBPC inhibitor.

Various transformer and oil characteristics were obtained during the period of test reported. Such characteristics included many of the accepted electrical, physical, and chemical tests in common usage throughout the industry.

From the data obtained to date from these unfinished tests, it is concluded that the DBPC inhibitor is an effective oxidation inhibitor when oxygen is available and will result in not less than three times the oil life for inhibited normal oil based upon the criterion of the first appearance of sludge.

Because of the attractive characteristics of this inhibitor with normal oil as an oxidation inhibitor, it has been studied with some care to see if there were any characteristics which would prove objectionable in its use in transformers. While we have found none that we regard as serious, it seems worth while to note some of the characteristics of the normal oil plus the DBPC inhibitor that differ from those normally accepted for conventional oil. It has been determined that while the dielectric strength of the oil is not reduced for inhibitor additions in the normal concentration range of 0.3 per cent by weight, a definite reduction of the order of 20 per cent was secured for inhibitor concentrations of the order of 20 per cent by weight. This indicates the desirability of dispersing heavy concentrations before energizing equipment.

At normal levels of inhibitor concentrations in conventional oil, the moisture saturation level is increased slightly, but this should not be a serious fault with proper attention to maintenance and particularly where the supply or introduction of moisture is limited in modern transformers.

The inhibitor effectiveness in normal oil apparently decreases at high temperatures in the range of 120 degrees centigrade. This should not detract from its proved value in the operating range of full load and normal overload.

While these transformer studies are incomplete and it is our intention to continue until after the inhibitor has become exhausted, it is indicated that the oxidation bomb test and possibly the 100-degree-centigrade oil power factor test may be useful tools for predicting the approaching end of the inhibitor life period of DBPC inhibited oil in service.

It also should be noted that the reported studies do not form a basis directly for evaluation of benefits to be derived from the use of the inhibited oil in transformers equipped with oil preservation means, nor do they embrace all of the criteria necessary to successful operation in other types of apparatus.

The indication that the life of normal oil is extended by the order of two to three times when DBPC is added to the extent of 0.3 per cent and where oxygen is not completely excluded may be useful in economic evaluations for the use of this inhibitor in normal oils.

Digest of paper 51-260, "Relative Performance of Normal Oils With and Without DBPC Inhibitor in Semisealed Transformers," recommended by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

E. D. Treanor and E. L. Raab are both with the General Electric Company, Pittsfield, Mass.

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Block Diagram Network Transformation

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Block diagram networks consisting of linear unidirectional elements form the basis for this simple and direct method of transforming and reducing networks for analysis. Particularly applicable to servomechanisms and control circuits, this method is similar in approach to Y-delta transformation and series-parallel reduction for solving ordinary networks.

ANY PART OF a closed loop system may be represented by a unidirectional element or by unidirectional elements in combination. This follows directly from the dynamic equations of a system. For instance, the differential equation

$$y=A_n\frac{d^nx}{dt^n}+A_{n-1}\frac{d^{n-1}x}{dt^{n-1}}+\ldots+A_1\frac{dx}{dt}+A_0x$$

written in Laplace transformed form is

$$y=(A_ns^n+A_{n-1}s^{n-1}+\ldots+A_1s+A_0)x$$

If x and y are regarded as signals, and the operational coefficient as an element, either of the network representations shown in Figures 1*A* and 1*B* will define accurately the relationship between x and y. The first representation would be used if the signal had its origin as x and were transformed to y; or, stated another way, if the driving function were x and the resultant response were y. The second representation would be used if the signal had its origin as y and were transformed to x.

If an equation consists of three variables which are related as either a sum or difference, such as

$$x\pm y=z$$

the equation may be represented as a summing point as shown in Figure 1*C*. It is convenient to write the equation near the summing point to avoid confusion as to whether the two signals x and y are added or subtracted to give z.

When an equation has more than two variables, it may be considered as several equations each having one or the other of the forms described here. Each of the separate equations can be represented by a summing point or an element. The elements and summing points then can be joined to represent the complete equation since some of the variables will appear in two different equations. As an example, the equation

$$x=(A_2S^2+A_1S+A_0)y+(B_2S^2+B_1S+B_0)z$$

may be written separately as three different equations

$$x=a+b$$

$$a=(A_2S^2+A_1S+A_0)y$$

$$b=(B_2S^2+B_1S+B_0)z$$

The first of these equations is represented as a summing point, and the second and third as elements as shown in Figure 1*D*. The three separate representations may be joined as shown by the dotted lines to represent the original complete equation since the variables a and b each appear in two of the separate equations.

In representing a set of simultaneous equations, there will be many elements and summing points all joined together. The representation takes on the form of a network and is called a "block diagram network."

A block diagram network consists of summing points, take-off points, and elements which transmit signals in one direction. A signal is any quantity such as current, voltage, pressure, mechanical displacement, temperature, and so forth, which serves as an actuating quantity at any point in a control system. A summing point is a point in the network where two signals are added or subtracted. A take-off point is a point in the network where a signal is diverted to follow more than one path to other points in the network. An element is any device or aspect of a device in the physical system which performs a change on the signal which passes through the element. The elements are unidirectional, that is, they allow signals to pass in

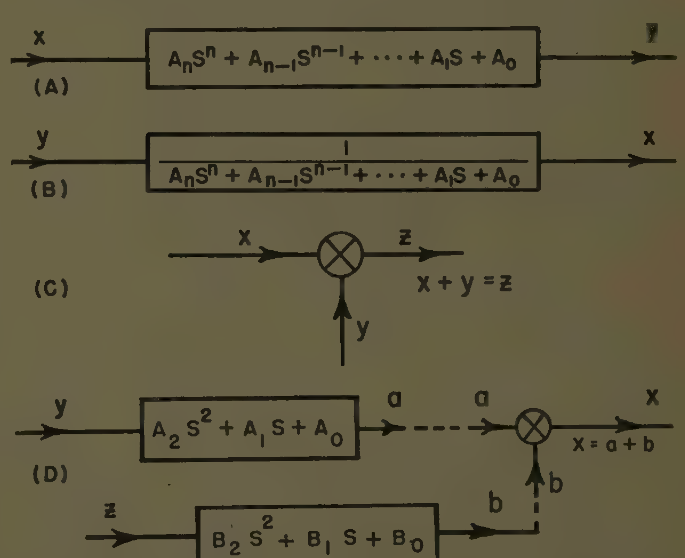

Figure 1. Block diagram network representation of differential equations. (A) and (B) represent an equation having two variables, (C) represents an equation with three variables with unity coefficients, such as x+y=z, and (D) represents an equation containing three variables

Essentially full text of paper 51-298, "Transformation of Block Diagram Networks," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, Portland, Oreg., August 20–23, 1951. Not scheduled for publication in AIEE *Transactions*.

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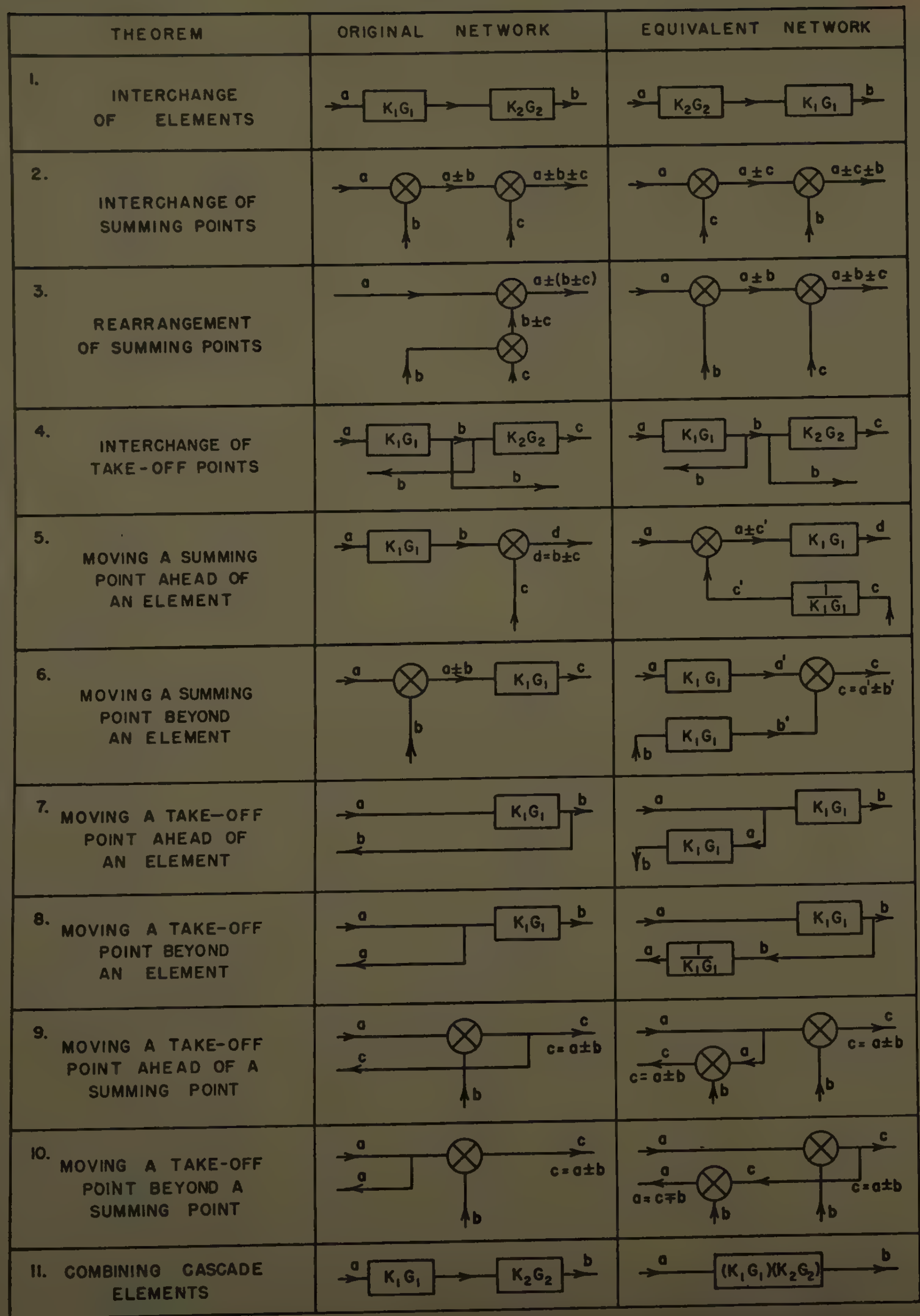

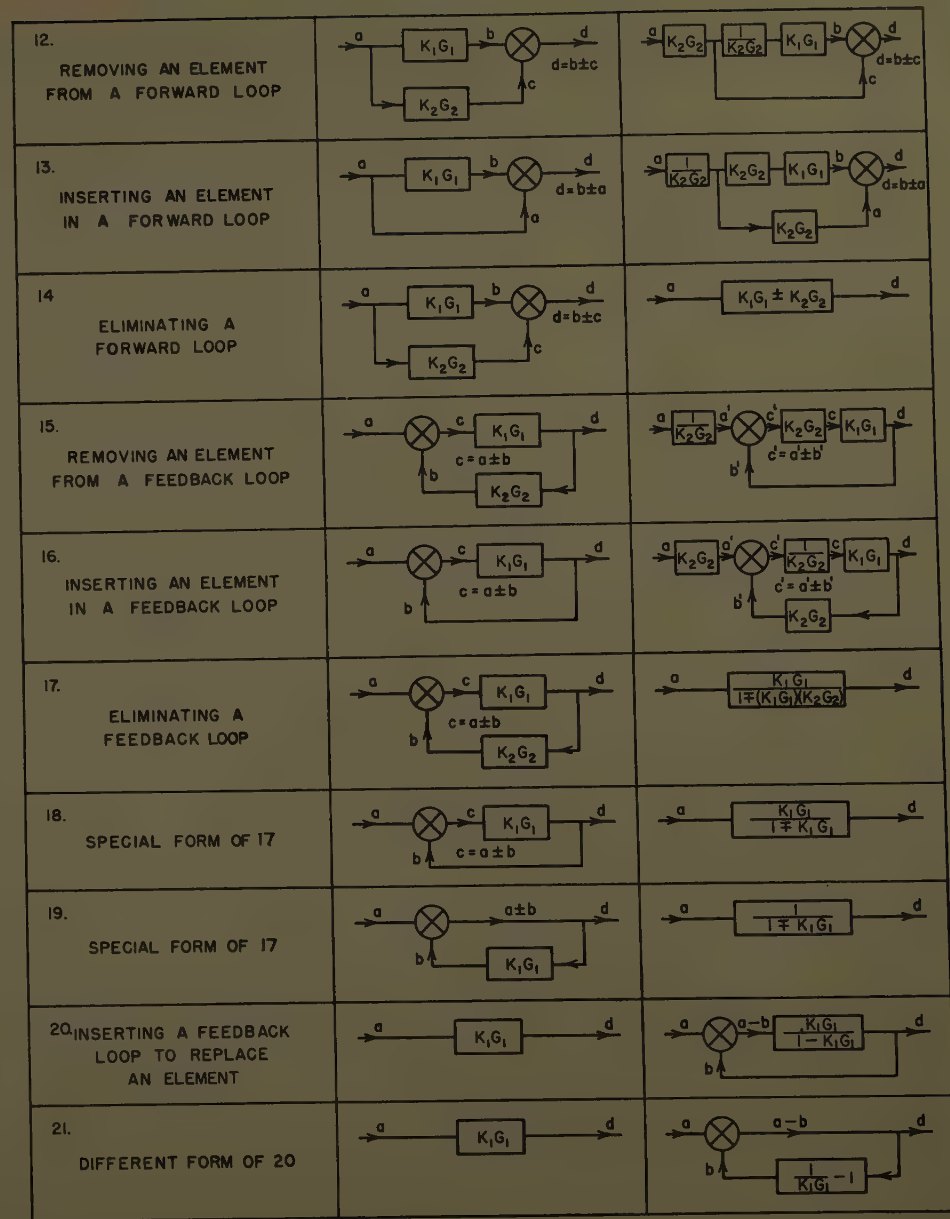

Table I. Theorems for the transformation and reduction of block diagram networks

one direction but not in the other.

In most control systems there is one input signal, the driving signal of the system, and one output signal which represents the quantity being controlled. All the other signals are related to these two signals and to each other. It is always possible to reduce such a system to a single equivalent element. In some servo applications it is necessary to study the system when subjected to simultaneous control signals and load torques. In such cases it is not possible to reduce the system to a single element unless the principle of superposition is applied, and separate reductions are made for the control signal input and the load disturbance signal input.

The elements in a block diagram network, in general, do not correspond exactly with the actual physical elements they represent except in special cases where the physical elements themselves are simple unidirectional elements. All the elements in the block diagram and the manner in which they are connected are obtained from the differential equations of the system they represent.

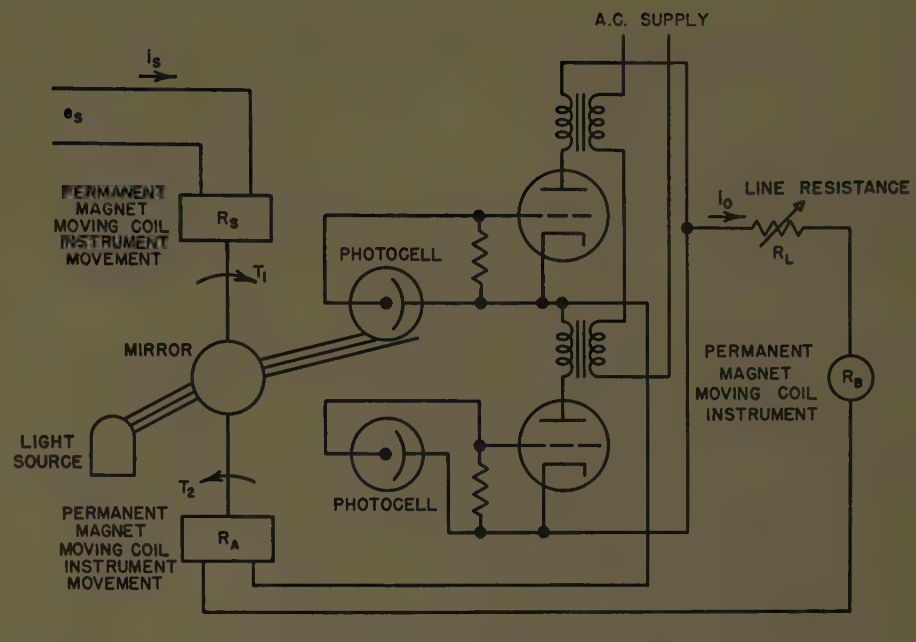

Figure 2. A closed loop control telemeter system to illustrate the block diagram network method

THEOREMS

To modify or reduce a block diagram network, theorems are needed which state how summing points, take-off points, and elements may be moved or modified without changing the over-all dynamic behavior of the system. The theorems may be stated most simply in block diagram form. The simplest and most important theorems are given in Table I. This list is sufficient in scope for the modification or reduction of complex networks. The symbol KG is used to represent the property of any general element. Where more than one element occurs, subscripts are used to distinguish between them. Signals are represented by a, a_1, b, b_1, and so forth.

The theorems are established by writing the differential equations for the two equivalent diagrams and showing that the equations are identical. Theorem 5 will serve as an example. The differential equation for the first diagram is

$$d=a(K_1G_1)\pm c$$

and for the second diagram is

$$d=[a\pm c(1/K_1G_1)]K_1G_1$$

When the second equation is multiplied out it becomes identical with the first. The proof of the other theorems follows in a like manner.

APPLICATION

The torque balance telemeter system shown in Figure 2 will serve as an example of how the block diagram network reduction method is applied. The system consists essentially of two permanent-magnet moving-coil instrument movements which are mechanically coupled to the same shaft. The incoming signal e_s is measured by the movement R_s, and is balanced by the outgoing current signal i_0 which is measured by the movement R_A. Any deviation from balance is measured by a light source, mirror, and photocell arrangement which controls the output of an amplifier which supplies the output current i_0. The current i_0 is measured by an indicating instrument

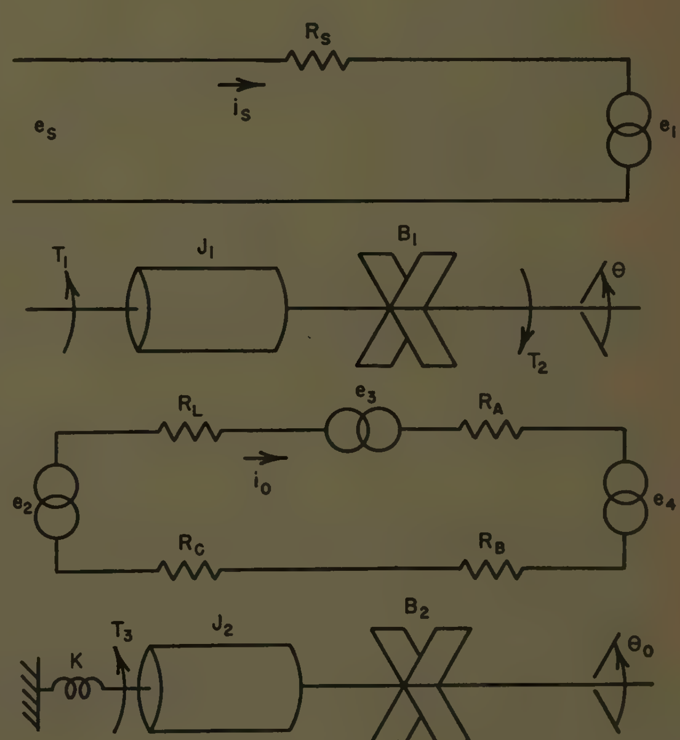

Figure 3. Equivalent electromechanical circuit of the system in Figure 2

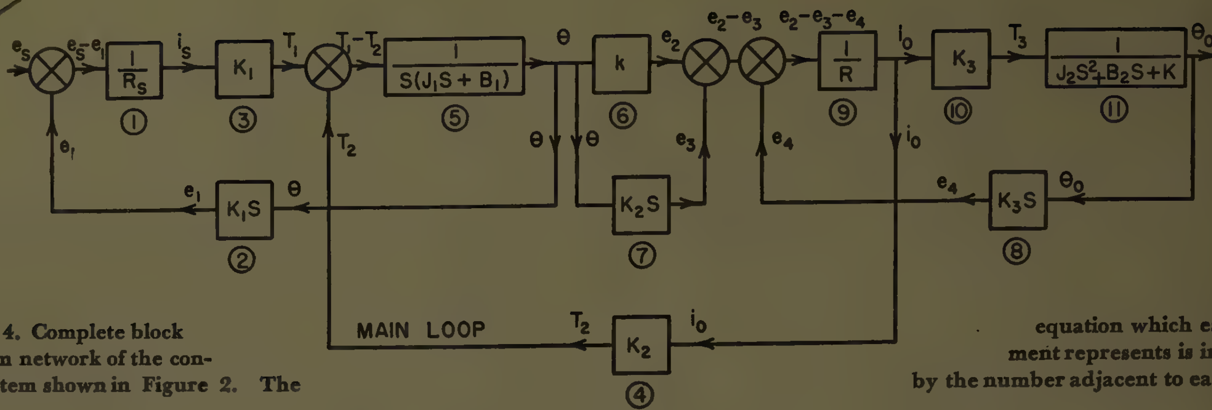

Figure 4. Complete block diagram network of the control system shown in Figure 2. The equation which each element represents is indicated by the number adjacent to each block

R_B which gives the reading of the quantity e_s at the remote station R_B.

The equivalent electromechanical circuit for the system is shown in Figure 3. The voltages e_1, e_3, and e_4 are the voltages generated in the electric circuits by virtue of the motion of the three permanent-magnet moving-coil move-

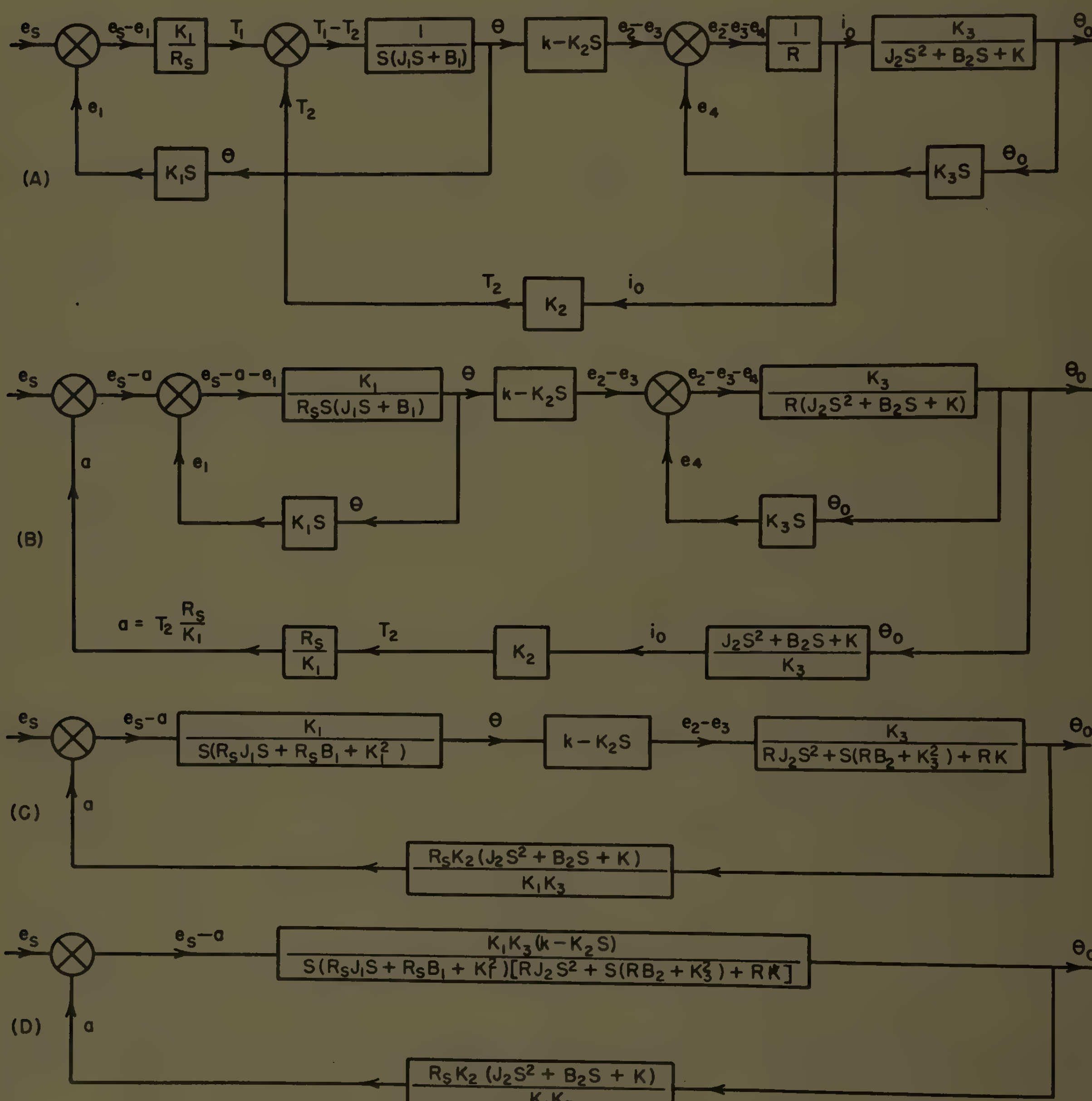

Figure 5. Steps in reducing the block diagram network of Figure 4. (A) Cascade elements combined and forward loop for e_3 eliminated. (B) Summing point for T_2 moved to the left and the take-off point for i_0 moved to the right. (C) The two inside loops eliminated. (D) Cascade elements combined

ments. k is the control ratio of the error measuring system and the amplifier. e_2 is the equivalent voltage generated in the amplifier output circuit by the displacement angle θ and R_c is the output resistance of the amplifier. K_1, K_2, and K_3 are the electromechanical coupling coefficients of the input instrument movement, the feedback instrument movement, and the output instrument movement respectively. The differential equations for this system in Laplace transformed form are

$$e_s = R_s i_s + e_1 \text{ or } i_s = (e_s - e_1)/R_s \tag{1}$$

$$e_1 = K_1 S\theta \tag{2}$$

$$T_1 = K_1 i_s \tag{3}$$

$$T_2 = K_2 i_0 \tag{4}$$

$$T_1 - T_2 = (J_1 S^2 + B_1 S)\theta \tag{5}$$

$$e_2 = k\theta \tag{6}$$

$$e_3 = K_2 S\theta \tag{7}$$

$$e_4 = K_3 S\theta_0 \tag{8}$$

$$e_2 = Ri_0 + e_3 + e_4 \text{ or } i_0 = (e_2 - e_3 - e_4)/R \text{ where } R = R_A + R_B + R_C + R_L \tag{9}$$

$$T_3 = K_3 i_0 \tag{10}$$

$$T_3 = (J_2 S^2 + B_2 S + K)\theta_0 \tag{11}$$

The block diagram network which represents this set of equations is given in Figure 4. It is obtained by laying out signal paths, summing points, and elements for each equation which express the same relationship as the equation. Variables in the equation are represented as signals, and coefficients as elements. For instance, equation 1, $i_s = (e_s - e_1)/R_s$, is represented by the first summing point and the first element in Figure 4. The other equations are interpreted similarly and added to the network.

The network may be reduced to a single loop most directly by moving the summing point for the main loop to the extreme left, the take-off point for the main loop to the extreme right, eliminating the three resultant internal loops, and combining cascade elements. This process is carried out in Figure 5 by use of the theorems in Table I.

The algebraic operations necessary to carry out this reduction are much less in number than those necessary to eliminate variables in the original equations to achieve the same result. This is the principal advantage of the reduction method; but it has the additional advantage of giving specific graphical significance to the algebraic operations which are performed. This is a great aid in carrying through long algebraic computations without making errors.

The final reduction may be expressed in several different forms which may be analyzed to give information about the behavior of the system. The final loop may be eliminated

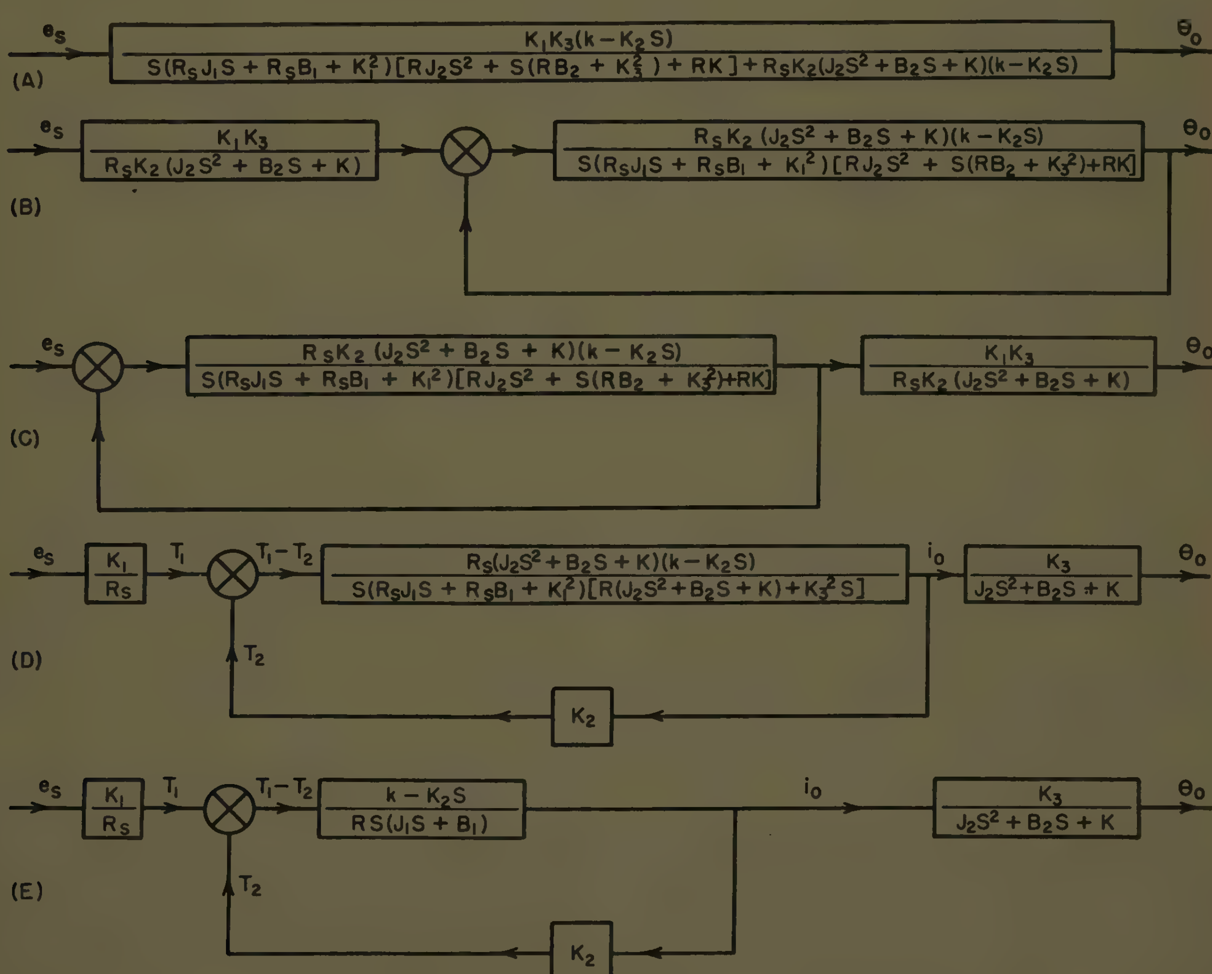

Figure 6. Different reduced forms of the block diagram network of Figure 4. (A) Output-input relationship. (B) and (C) Element eliminated from the feedback loop. (D) Reduced form with main feedback loop preserved. (E) Approximate form when the back electromotive force is neglected in the input measuring and output indicating instrument movements

to obtain the output-input relationship as shown in Figure 6*A*. Or the element in the feedback path may be removed giving the form shown in Figure 6*B* or the form shown in Figure 6*C*. That these last two forms are equivalent follows from theorem 1 where $K_1G_1 = (K_1K_3)/[R_sK_2(J_2S^2 + B_2S + K)]$ and K_2G_2 is the other element including the feedback loop and summing point.

Another reduction, which maintains the main feedback loop in its actual form, is shown in Figure 6*D*. This form may be obtained from that of Figure 6*C* by splitting the element $K_1K_3/[R_sK_2(J_2S^2 + B_2S + K)]$, putting the part K_1/R_sK_2 on the left side of the loop, and inserting K_2 back into the feedback path. This will preserve the signals T_1, T_2, and i_0 as shown. This reduced form also could be obtained from the original network of Figure 4 by moving the secondary loops inside the main loop, and then eliminating the secondary loops. This form of the reduction illustrates the effect of the back electromotive forces of the input and output indicating instruments. If there were no back coupling from these instruments, the system could be analyzed by considering the relationship $T_1 = e_sK_1/R_s$, the main feedback loop as shown in Figure 6*E*, and the dynamics of the output indicating instrument. These three analyses could be made separately, as the dynamic response of one would not be dependent upon the response of the others. This same method of approach may be used with the actual network, but the transfer function for the main loop must be modified as shown in Figure 5*D* to include the effects of the back electromotive forces in the input and output instrument movements. The form of reduction shown in Figure 5*D* shows clearly how the back electromotive forces are reflected into the main loop, and how they modify the transfer function of the main loop.

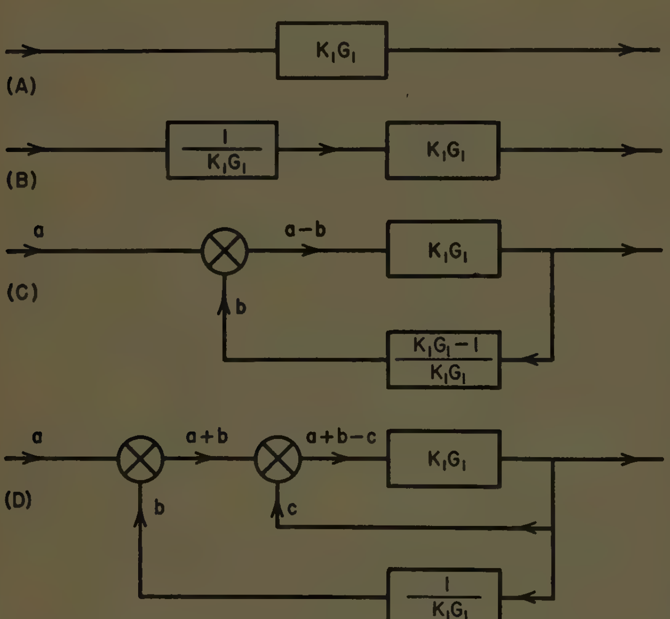

Figure 7. Methods for obtaining perfect dynamic response. (A) Original element. (B) Perfect response obtained with cascade. (C) Perfect response obtained with single feedback loop. (D) Perfect response obtained with double feedback loop

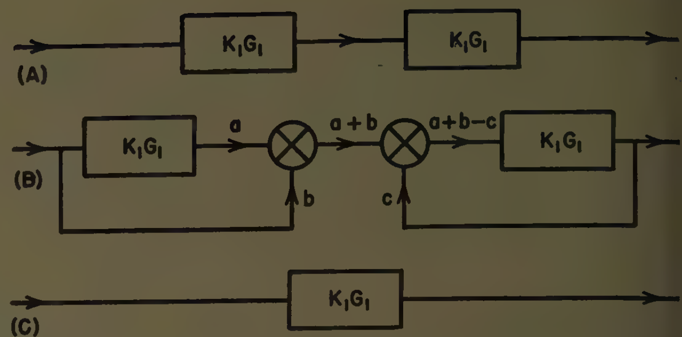

Figure 8. Improvement in dynamic response of two identical elements in cascade. (A) Two identical elements in cascade. (B) Improved response obtained by addition of forward and feedback loops. (C) Dynamic equivalent of (B)

APPLICATION TO SYNTHESIS

THE BLOCK diagram network also lends itself to the study of specific problems relating to synthesis. As an example, the problem of eliminating the dynamic lag of a particular part of a control system by corrective elements may be approached in general terms by starting with an element 1 (unity) and by introducing combinations of elements which maintain the over-all unity response. Working this way, the theorems in Table I are applied in reverse order from the way they are applied in making network reductions.

Three perfect systems are shown in Figure 7. The first utilizes a cascade element, the second a single feedback loop, and the third a double feedback loop. Elements which are reciprocally related to the original element must be added. From the standpoint of synthesis of practical physical elements, the reciprocal relationship is impossible to achieve, but it may be approximated over a desired frequency range. Such approximation is inherent in all the methods of achieving satisfactory stability in closed-loop control systems.

Figure 8 illustrates a method of improving the response of two identical elements in cascade. By addition of a forward and backward loop as shown, the response becomes identical with that of the single element K_1G_1.

Block diagram networks provide an effective labor-saving technique for the study of closed-loop control systems. Network transformation processes are useful for analyzing the effects of changes in the system. Network reduction procedures provide a simple and direct method of reducing multiloop systems to single-loop systems for analysis by the use of single-loop servomechanism theory.

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Design of Permanent-Magnet Alternators

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PERMANENT-MAGNET alternators have been used for many years in small-sized units such as tachometer generators, governor frequency sources, and magnetos, but until recently have not been adopted widely as primary sources of power. With the development of dispersion-hardening alloys typified by the Alnico family and their application to rotating machinery, the permanent-magnet alternator has assumed a more important role for power applications. In some ratings these machines weigh less, consume less space, and cost less than d-c excited alternators. The saving in weight and space is accomplished chiefly by the elimination of the d-c exciter. When the exciter is absent, commutation problems are eliminated. Hence, these machines are assuming an important role for portable, aircraft, and other applications in which the saving of weight is an essential factor.

In beginning the design of a permanent-magnet synchronous machine the designer is faced with several problems and factors which are different from those encountered in the design of standard machines. They are: 1. the effects of demagnetizing forces upon permanent-magnet materials; 2. the type of magnet stabilization to be utilized; 3. methods for reducing the voltage regulation; and 4. methods of shielding the magnets from transient demagnetizing forces. Each of these aspects of the motor design now will be considered.

A permanent magnet may be thought of as a source of magnetomotive force possessing a reluctance which is a function, not only of the flux density, but also of its previous magnetic history. The relation between the flux density associated with the magnet and the magnetomotive force available for use in the external magnetic circuit is the demagnetization curve B_rQH_c, Figure 1. If OR represents the relation between the external magnetomotive force and flux density, the point of stable operation of the magnet will be at Q. If the magnet is now subjected to an external demagnetizing force F_A, the operating point will be at Q'. When F_A is removed, the magnet will not recover to Q but rather along a minor hysteresis loop to OR. This minor hysteresis loop may be thought of as a straight line parallel to the slope of the major loop at B_r. Any subsequent demagnetizing magnetomotive force less than or equal to F_A will result in operation along the minor loop $Q'A$, and the magnet is said to have been stabilized for magnetomotive forces of magnitudes equal to or less than the external demagnetizing force, F_A.

Stabilization may be carried out either in air or in the machine. Air stabilization allows the magnets to operate into the high reluctance of the air gap between the poles with the rotor out of the machine. Stabilization in the machine involves application, with the rotor in the machine, of a demagnetizing force equal to the maximum expected in service, which in most cases would be a sudden short circuit.

Once the magnets have been stabilized, the operating characteristics of a permanent-magnet alternator are virtually the same as a standard alternator operating at a constant field current. Since low voltage regulation generally is necessary, departure must be made from the design employed for standard machines utilizing a voltage regulator. There are three possibilities: 1. reduce the armature turns; 2. use series capacitors; and 3. use interpolar shunts.

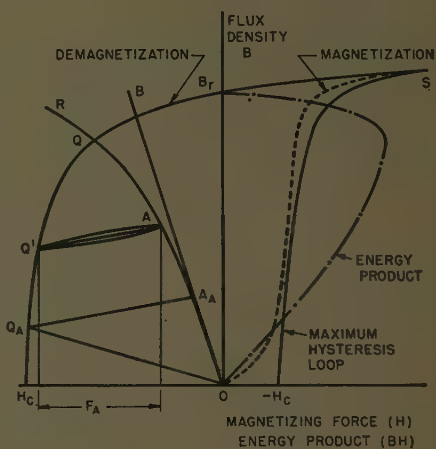

Figure 1. Magnetization, demagnetization, and energy product curves for a permanent-magnet material. Note that for positive magnetizing forces a reduced scale is employed

In a synchronous machine, the initial short-circuit armature reaction magnetomotive force may be five to eight times the full-load value and can seriously demagnetize the magnets. The effect of transient demagnetizing forces may be reduced greatly, however, by casting the entire rotor in aluminum. This, in effect, places an infinite-bar cage winding on the rotor. Any change in the air-gap flux induces currents in the cage which tend to oppose the change in air-gap flux. The same general effect can be achieved by plating the poles with copper. The latter method has the advantage of requiring less air-gap space for the plating material.

The fact that the field winding is absent on permanent-magnet machines makes increased rating possible in cases where electromagnetic machines are limited in rating by the ability of the field winding to dissipate heat. Similarly, the absence of a field winding reduces the losses associated with a given machine, thus increasing the efficiency. A 15-kva 220-volt 3-phase 60-cycle 1,200-rpm machine has an efficiency of 82.5 per cent with the electromagnetic field, while it shows an efficiency of 90.9 per cent with a permanent-magnet field under the same load conditions.

Digest of paper **51-296**, "Design of Permanent Magnet Alternators," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, Portland, Oreg., August 20–23, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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Field Screening Test for Used Insulating Oils

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IN ORDER to field classify used insulating oils into "those suitable for continued service" and "those in doubtful condition," the American Gas and Electric System about 10 years ago developed and put into use a test kit, as shown in Figure 1, for measuring neutralization value and color of oils. These test kits were put into the hands of the field insulation test crews which already had facilities for measuring oil power factor, with the request that oil from each piece of equipment be tested for neutralization number, color, and power factor and examined for visual presence of sludge.

The screening limits as initially set and as modified in 1950 as a result of many of the oils in bad condition having been replaced, reclaimed, or otherwise restored to acceptable condition, are as follows:

	Initial	1950
Neutralization value (milligrams potassium hydroxide per gram)	0.7	0.5
Color (union)	7	5
Power factor (20 degrees centigrade), per cent	1.0	1.75
Visual evidence of sludge	Present	Present

Those oils which do not exceed screening limits are considered to be in acceptable condition whereas samples of oils exceeding the limits are sent to the Company's general laboratory for further examination and recommendations as to treatments the oils should receive.

The determination of color of an oil is simple, involving only the matching of a standard color in the disc of a Hellige Color Comparator with that of the oil. The determination of neutralization value, however, is more difficult and as it is done conventionally is hardly practical for field use. The objective was to develop a procedure to permit making all of the tests volumetrically at ambient

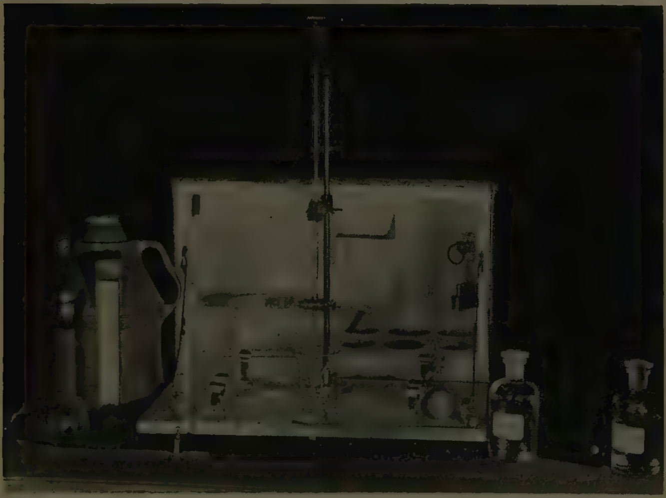

Figure 1. Field test kit apparatus set up for use

temperature and to provide a means of locally standardiz- ing the titrating solution.

The test consists of preparing a mixture of a known volume of the oil under test and a methyl alcohol–distilled water–phenolphthalein solution and, without heating, titrating it to the end point of the indicator with a standard- ized potassium hydroxide (KOH) solution. A factor designating the strength of the KOH solution is determined by a similar procedure when using a standard oil of known neutralization number.

To determine the neutralization value of an oil:

1. A Cassia flask is filled to the 100-milliliter mark on the flask neck with the alcohol-water-phenolphthalein solution and then to the 105-milliliter or 110-milliliter mark on the neck with the oil of unknown acidity, depend- ing upon whether the oil has a color number of less than or greater than 5.

2. The mixture then is transferred to a beaker and, while stirring, titrated with the KOH solution from a conventional burette until the color of the alcohol-water layer changes to a definite pink.

3. The neutralization value is

$$\frac{\text{milliliter of KOH solution used} \times \text{KOH factor}}{\text{milliliter of unknown oil used}}$$

High precision in the neutralization value determination is not required because the test is only for a general classi- fication of the oil. However, in a comparison of the results on about 100 samples using the test kit as against the American Society for Testing Materials (ASTM) presently effective Standard *E974–48T*, most of the values fell within the ASTM stipulated limits of accuracy for their method.

Since the test kits were put into use, approximately 2,600 oil samples have been field tested. Of that number about 325 samples were sent to the general laboratory. Laboratory recommendations as to the attention to be given the batches represented by these samples were divided as follows: 62 per cent required blotter pressing only; 2 per cent required special filtering to remove a silicate contaminant from core laminations; 28 per cent required reclamation by fuller's earth; and 8 per cent were considered to be beyond salvaging.

It is apparent that suitable field screening tests for used insulating oil save a great deal of laboratory work. Conse- quently, such tests form a vital step demanding attention by utilities interested in insulating oil preventive main- tenance.

Digest of paper 51-261, "Field Screening Test for Judging the Condition of Used Insulating Oils," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Not scheduled for publication in AIEE *Transactions*.

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A Magnetic Tape Oscillograph for Power System Analysis

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A unique magnetic pickup device makes the magnetic tape recorder adaptable to the recording of power system transient phenomena. Besides eliminating the inconvenience and expense of conventional photographic methods, this technique produces a permanent record starting well in advance of the transient being recorded.

THE inconvenience, expense, and delay of obtaining automatic records of power system phenomena and of obtaining records during staged field tests with conventional oscillographs has prompted the investigation of magnetic recording techniques for this purpose. While there is an abundance of information in engineering literature on the recording of sound by magnetic tape or wire, little information is available on the applicability of magnetic recording to the field of oscillography. A review of current techniques and apparatus discloses that applicability to this field is limited by lack of a suitable pickup device. The development of a unique magnetic pickup device described here adapts magnetic tape recording to the field in which conventional oscillographs of both the automatic and laboratory types usually are employed. The advantage of reusability of the recording medium inherent in magnetic recording permits convenient incorporation of the "anticipator" feature in an automatic oscillograph. Transcription of the magnetic records at reduced tape speed by pen and ink recorder considerably enhances both automatic and laboratory oscillograph applications by elimination of the usual photographic processing. Both are made possible by the novel pickup device which delivers an output voltage independent of the speed of the tape. Construction and test of a model oscillograph using the new pickup device furnish a basis for design of a practical automatic recorder.

The possible advantages of magnetic recording for oscillographic purposes have long attracted interest. One of the first is the fact that the magnetic recording medium can be erased and reused practically an unlimited number of times. This permits continuous recording of phenomena, including steady-state conditions, even where only transients or abnormal conditions are of interest. Thus, the transcription or examination of a small portion of the recorded information is substituted for the fast-starting feature of the present conventional automatic oscillograph. In this substitution two benefits may be gained: the mechanical difficulties attending any fast-starting feature are eliminated and the steady-state conditions preceding the transient are recorded. In conventional equipment, the recording is started by the transient or abnormal condition itself.

The economic aspect of the magnetic recording technique has not been overlooked. However, while it previously has permitted the continuous type of recording just mentioned, subsequent transcription of the desired portions of the recorded information has required some of the conventional photographic recording material and the conventional oscillograph itself. Although complete elimination of photographic materials and the delay and inconvenience of photographic processing is a desirable goal, it has not generally been achieved.

Essentially full text of paper 51-239, "A Magnetic Tape Oscillograph for Power System Analysis," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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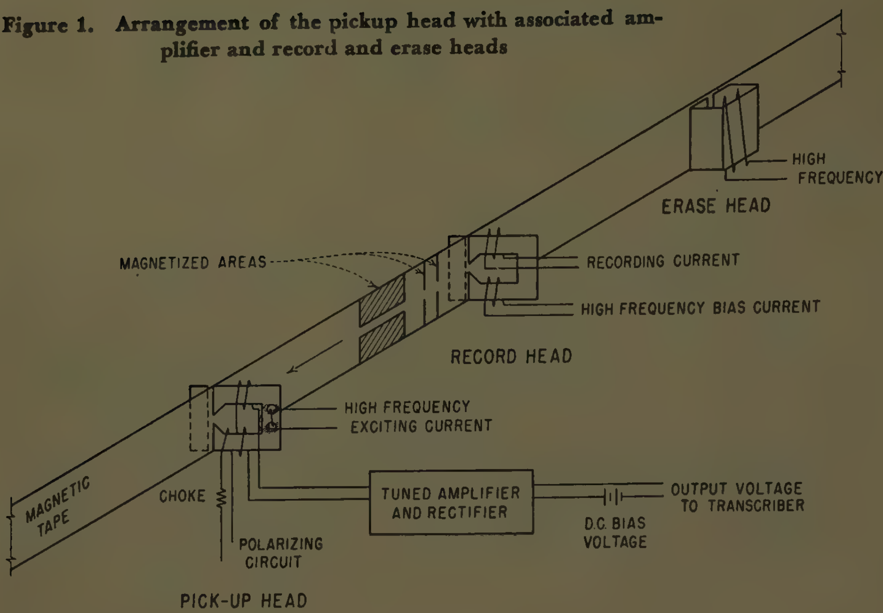
PREVIOUS LIMITATIONS

A BRIEF REVIEW of some of the principles employed in magnetic recording and reproduction or transcription may clarify its previous limitations. In the most usual applications, the electric current representing the phenomenon to be recorded is passed directly through the main coil of the recording head to produce magnetic impressions on the recording medium. A high-frequency bias current simultaneously applied to a coil of the recording head makes magnetic impressions closely proportional to the recording current over a wide range of current.[1]

For applications in which an especially wide range of frequencies is to be recorded, such as sound recording, self-demagnetization of the recording medium becomes a limitation in the recording of the higher frequencies. Self-demagnetization is a function of the ratio of the length to thickness of the small magnets set up by the recording process in the magnetic medium.[2] It is thus also a function of the ratio of frequency to speed of the recording medium. It may be regarded as a magnetic short-circuiting of the flux as the magnetic poles get closer together. However, for available recording mediums and reasonable speeds the frequency at which self-demagnetization becomes appreciable is well above the range required for power system oscillographic applications. Thus, the recording process is accomplished readily by well-known means with suitable accuracy for the purposes described in this article.

The usual means of reproducing the information recorded as magnetic impressions on the tape suffer more limitations than the recording process. The most commonly used pickup device is similar to the recording head. In fact, a single unit often serves both purposes for audio applications. The magnetic flux from the recording medium threads

Figure 1. Arrangement of the pickup head with associated amplifier and record and erase heads



along the magnetic circuit of the pickup and through the pickup coil. The only voltage produced in the pickup coil is that due to the changes of magnetic flux. The rate of change of the flux and hence, for a given recording current, the voltage produced in reproduction is proportional to the frequency. If the frequency drops to zero, as for direct current, the output voltage becomes zero. For finite frequencies in the lower range where self-demagnetization is negligible, if the frequency doubles the output voltage doubles. Since output voltage is a function of frequency, and frequency during reproduction is a function of the speed of the magnetic medium past the pickup head, the output voltage is also directly a function of the speed of reproduction. Thus, aside from the inaccuracies introduced by drive speed variations, the range of applications to which this form of magnetic recording and reproducing has been adaptable has been limited by the ability of integrating and equalizing networks to compensate for the inherent characteristics. In the field of power system oscillography where transients and direct quantities or components are of importance, it is apparent why this form of recording and reproduction has not become popular.

A scheme of magnetic recording and reproducing which overcomes some of the foregoing difficulties is that of recording a carrier frequency which is frequency-modulated as a function of the phenomenon to be recorded. Reproduction is then essentially a process of frequency discrimination. This technique has the obvious possibility of eliminating amplitude modulation and any inaccuracy due to nonuniformity of the magnetic medium. However, it is subject to errors due to variations in drive speed in both the recording and reproducing processes, and it is limited in range of response to a fraction of the range of frequencies[3] which can be resolved by the magnetic medium. The requirement for a separate oscillator to be frequency-modulated by each quantity to be recorded imposes additional equipment.

A PICKUP OF REQUIRED CHARACTERISTICS

FROM THIS review of the characteristics of magnetic recording and reproducing systems, it is evident that for full exploitation of the possibilitie of magnetic recording for oscillo graphic purposes a pickup head i needed which will produce an out put voltage proportional to the mag netomotive force exerted upon th pickup head by the portion of th tape being examined, of polarit dependent upon the polarity of th magnetomotive force, and inde pendent of the speed of recording o reproduction.

The pickup head to be describe meets these requirements by the ex pedient of causing the reluctance o its magnetic circuit to vary in a cyc lic manner at a frequency well abov the highest frequency to be recorded Of various possible means of varyin the reluctance, such as by me chanical variation of air gaps in the magnetic circuit, me chanical strain of a portion of the magnetic circuit, or mag netic saturation of a portion of the magnetic circuit, th latter was chosen as offering the most practical solution No moving parts are involved, permitting desirable sim plification, and the frequency with which the reluctanc can be varied is limited only by hysteresis and eddy curren losses in the magnetic circuit.

The arrangement of the recording, pickup, and eras heads is shown schematically in Figure 1. The magneti circuits of the record and pickup heads are arranged t utilize a combination of transverse and perpendicular mag netization of the tape instead of the more common longi tudinal magnetization. This is necessary to permit accu rate reproduction of square waves or d-c pulses of unlimite duration. The pickup head has its magnetic circuit pierce by two small openings through which an auxiliary excitin coil is threaded to produce cyclic saturation of the part o the magnetic circuit around the two small holes in th pickup in Figure 1. As far as the pickup alone is concerne greater sensitivity might be obtained by saturation of th entire magnetic circuit; however, the tape then would b demagnetized by the stray field set up. The balanced ar rangement of the saturating part of the magnetic circui serves to prevent appreciable stray field from the excitin frequency current from appearing at the pole faces whic contact the magnetic tape. It also balances the excitin frequency component of voltage out of the main picku coil. In this respect the device differs from other magneti pickups of which the authors have knowledge.

With this arrangement the effective reluctance of th magnetic circuit is increased once for each half-cycle of th exciting current so that the predominant voltage produce in the main pickup coil is of twice the exciting current fr quency and nearly proportional to the magnetomotive forc exerted by the tape on the pole pieces of the pickup. Pr duction of the double-frequency output voltage by th balanced saturating core section of Figure 2*A* is illustrate by Figure 2*B*. This idealized graphical illustration based on an assumed core material with a straight line ma

netizing characteristic and sharp saturation. This is a reasonable approximation of the characteristics of modern high permeability materials.

It must be recognized that choice of saturation of the magnetic circuit as a means of varying its reluctance represents some sacrifice in linearity of output to gain simplicity. Analysis of the performance of saturated inductors in magnetic fields[4] indicates that the second harmonic component of the output voltage e_2 is expressed by

$$e_2=\frac{4pNAH_e10^{-8}}{3}\left(\left[1-\left(\frac{H_m+H}{H_e}\right)^2\right]^{3/2}-\left[1-\left(\frac{H_m-H}{H_e}\right)^2\right]^{3/2}\right)$$

in which N is the number of turns; p is 2π times frequency of exciting field; A is the area of the core; H_e is the impressed (exciting) magnetizing force; H_m is the magnetizing force required to saturate the core; and H is the magnetizing force to be detected.

It is evident from the equation that e_2 is not a linear function of H; however, the relation between e_2 and H for $H_e=2$ and $H_m=1$, shown in Figure 3, indicates that an operating point can be chosen where the curvature is relatively slight. Although any curvature in this characteristic affects the over-all calibration curve of the instrument, a small amount of curvature can be tolerated for power system application, since an error of 5 per cent is common for automatic oscillographs and 2 per cent for portable recording equipment.

Figure 3 also illustrates that the alternating voltage e_2 is zero when H is zero and increases as H increases in either a positive or negative direction. This unpolarized characteristic is overcome readily, and the most nearly linear operating point is obtained at the same time, by the simple expedient of applying a unidirectional magnetic bias indicated by H_b. This is accomplished readily by adjusting the value of direct current in the polarizing coil shown in Figure 1 or by adjusting the relation of the pickup to a small permanent magnet. The output then is caused to vary about the

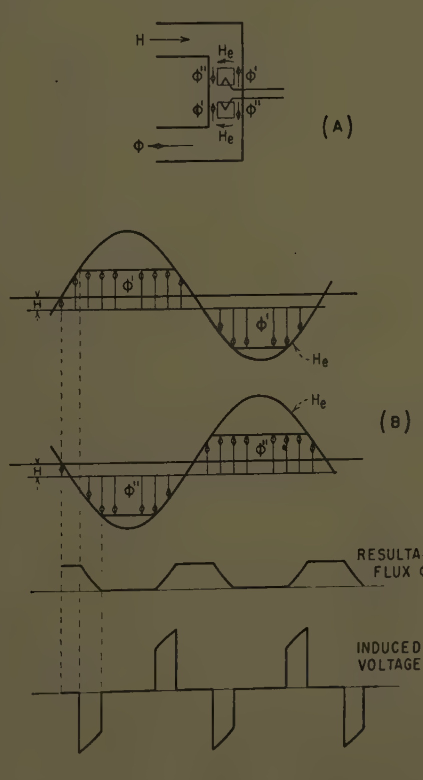


Figure 2(A). Magnetizing forces and fluxes produced in pickup. H is the magnetizing force to be detected (magnetomotive force per unit length of path); H_e is the magnetizing force of the exciting path; ϕ' is the flux in path 1; ϕ'' is the flux in path 2; ϕ is total flux $\phi'-\phi''$

Figure 2(B). Production of double frequency voltage in pickup coil by the magnetizing forces and fluxes of Figure 2(A)

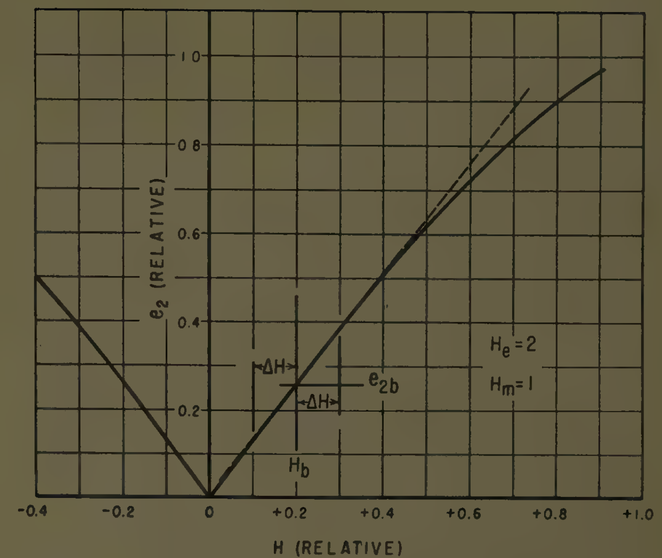


Figure 3. Variation of second harmonic component of output voltage with magnetizing force from the tape

point e_{2b} by the field from the tape ΔH. Thus, the pickup meets the requirements considered necessary to permit full exploitation of the possibilities of magnetic tape recording for oscillographic purposes on power systems.

EXPERIMENTAL MODEL

OSCILLOGRAPHIC APPLICATIONS require an associated oscillator, amplifier, transcriber, and tape drive mechanism in addition to the magnetic tape and record, reproduce, and erase heads. These components have been assembled into an experimental model to verify the performance indicated by the foregoing theory.

The physical arrangement of the pickup, record, and erase heads is essentially as illustrated in Figure 1. Permalloy was used for the magnetic circuit of the pickup head. In this application both the high permeability and low saturation density of this material are of advantage. Although facilities were not available for properly annealing the material after fabrication, a compromise anneal, which yielded considerably less than the best performance obtainable, was nevertheless satisfactory for the purpose. The magnetic circuit of the record head was made from silicon iron because of the higher allowable flux density. A small link of core material is used on the back side of the tape opposite the pickup head and opposite the record head to reduce the magnetic reluctance of the circuits and to reduce the influence of stray fields.

The cores of the record and pickup heads were made from 0.015-inch stock which was the thinnest material at hand. Although a reduction in thickness of the pole pieces theoretically would permit a reduction of the minimum tape speed, it was calculated that with the 0.015-inch-thick pole pieces a tape speed of 1.8 inches per second would resolve a 60-cycle square wave and a speed of 5 inches per second would resolve a 60-cycle sine wave with only 1 per cent distortion. This was considered a sufficiently low minimum speed for test purposes. While thinner pole faces in a practical model would increase the frequency range of the instrument, the reduction of tape speed is of no particular ad-

vantage when an endless belt is used. The erase head used embodied no new principle. However, the orientation used was such as to produce a saturating high-frequency field in a longitudinal direction along the tape. Thus, even if minute magnetized areas are left in the tape by the erase system at the higher tape speeds, this remanent magnetism is perpendicular to the active recorded fields.

The electronic elements are assembled on one chassis in order to use one power supply. Such a combination also affords a desirable reduction of space required. The functions of the various electronic components are nevertheless sufficiently independent to permit separate explanation.

One oscillator serves three purposes: supplying the high-frequency bias current for recording; supplying the high-frequency exciting current for the pickup head; and furnishing high-frequency power for the erase system. The power requirements of the erase system are the greatest of the three requirements and it is logical that a frequency should be chosen which will afford reasonable efficiency in this function. A frequency of 20 kc was selected for the experimental assembly on this basis. A push-pull oscillator circuit was used because of its inherent good waveform and high power output. As it is conventional in design, no diagram is included. A series resonant circuit is used with the erase head to simplify obtaining maximum power transfer. Delivery of the high-frequency bias current to the record head is effected through a control rheostat and through a winding on the record head separate from the main recording winding to keep the recording circuit isolated as much as possible. A resistance is used in series with the exciting coil of the pickup head to swamp out the effect of nonlinear impedance of this saturating circuit on the waveform of the exciting current. The value of the exciting current, although not critical, is adjusted for optimum performance by this series resistor.

The amplifier contains a tuned section which operates at 40 kc, the second harmonic frequency of the exciting current to the pickup, a rectifier-detector, and a d-c amplifier to drive the pen and ink transcriber.

The tuned amplifier section is conventional but uses a sharp cutoff pentode amplifier tube to maintain a mor[e] linear relation between input and output at high signa[l] levels. Here, too, the high amplification possible in tune[d] amplifiers is used to advantage. The first part of the de[-]tector-rectifier circuit is conventional, but to handle th[e] transcription of d-c phenomena from the tape the detecto[r] must be direct-coupled to the d-c amplifier section. Here [a] d-c bias voltage is inserted to cancel the residual voltag[e] produced by the unidirectional magnetic bias field applie[d] to the pickup head to obtain properly polarized performanc[e] and to shift operation to the best part of the magnetizatio[n] characteristic illustrated by Figure 3. A schematic dia[-]gram of the electronic amplifier is shown in Figure 4.

The only unusual feature of the tape drive mechanism [is] that an adjustable speed drive having a range of from 2 t[o] 15 inches per second is provided. A moderate tape spee[d] is used for recording and a low tape speed is used for tran[-]scribing in order to bring the frequency of the quantit[y] being transcribed within the range of accurate response [of] the transcribing pen.

The instrument used for transcribing the records ha[s] chart speeds of 5, 25, and 125 millimeters per second. Th[e] pen driving element is capable of reasonably flat frequenc[y] response up to 30 cycles per second. The instrument is [of] commercial design and needs no further description here.

TEST RESULTS

THE MINIMUM tape speed of 2 inches per second afforde[d] by the tape drive mechanism produced satisfactor[y] definition and amplitude in recordings of 60-cycle curren[t] as determined by examination of the play back with a[n] oscilloscope. However, at this speed appreciable distortio[n] occurs because the pole face width is an appreciable incr[e-]ment of the wave length. Recordings which were to b[e] transcribed were made at higher tape speeds in order to r[e-]duce the frequency during transcription to within the fla[t] frequency response range of the transcriber pen or to obtai[n] sufficient time spread on the transcriber chart. For th[is] reason tape speeds of from 5 to 15 inches per second we[re] used in recording and tape speeds of from 2 to 5 inches p[er] second were used in transcribin[g] the records. Distortion due to po[le] face width thereby was limited to [...] per cent or less. Samples of resul[ts] obtained are shown in Figure [5]. These sample oscillograms are se[-]lected to illustrate the capability [of] this form of recording. Figure 5[A] shows a 60-cycle sine wave. No[te] that the time spread is greater tha[n] ordinarily obtainable with an aut[o-]matic oscillograph. It is of intere[st] to note that the time spread may b[e] adjusted during the transcribin[g] process to any value desired by co[n-]trolling the relation between record[ing] tape speed and transcriber cha[rt] speed. Figure 5*B* shows the cap[a-]bility of the apparatus for resol[v-]ing and reproducing d-c pulses. T[...]

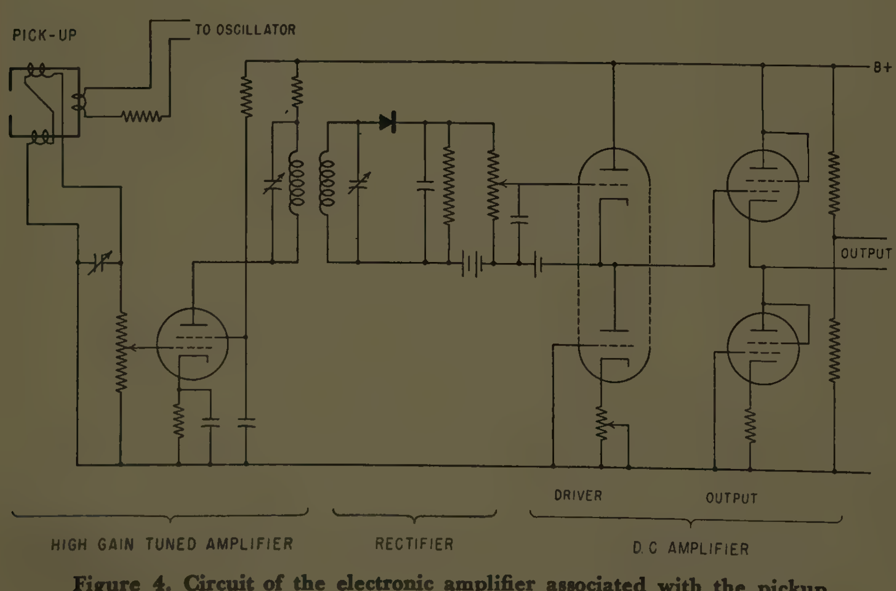


Figure 4. Circuit of the electronic amplifier associated with the pickup

pulses shown are of 3 seconds' minimum duration and were transcribed at the same speed as recorded. The curvature of the chart ordinate due to the circular movement of the pen arm is evident. A recorder which transcribes onto a rectangular scale chart would be preferable.

The recording of an alternating current with an initial offset shown in Figure 5*C* is of interest in that it shows the capability of the system to record and reproduce both d-c and a-c components. This current was produced in a reactor and hence shows only a d-c decrement. The a-c decrement commonly visible in the short-circuit current from synchronous machines is necessarily absent.

The trace shown in Figure 5*D* shows the distorted wave form of the exciting current of a transformer. The trace of Figure 5*E* was produced from a recording of a 60-cycle sine wave on a tape from which the previous higher frequency recording was not completely erased.

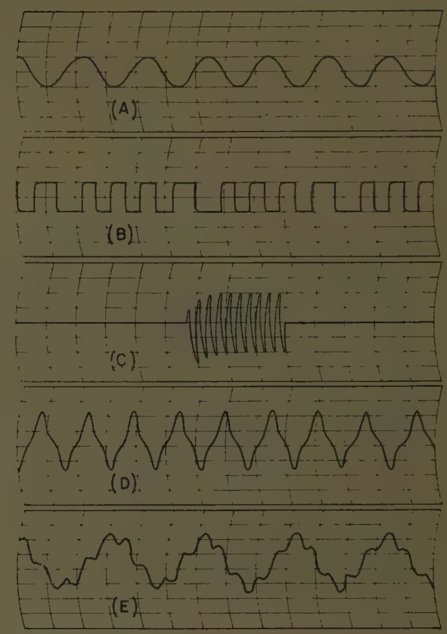


Figure 5. Oscillograms produced by the magnetic tape oscillograph
(A). 60-cycle sine wave
(B). D-c pulses
(C). 60-cycle wave with initial offset
(D). Transformer magnetizing current
(E). Complex waveform

POSSIBILITIES OF AN AUTOMATIC RECORDER

THE BURDEN IMPOSED by a recording head upon the circuit to be monitored may be made very small. In the experimental model 0.04 volt-ampere was sufficient to utilize the full magnetic range of the tape. Unlike the Duddell type galvanometers of conventional oscillographs with their inherent low impedance, the recording heads for magnetic recording can be constructed with a wide range of impedances. If minimum burden is of importance with the circuits to be monitored, the windings of the recording heads can be proportioned accordingly. Current shunts can be eliminated if necessary. High-impedance windings on recording heads for potential circuits will reduce the current requirement to a small fraction of that required by conventional oscillographs.

Since the currents or voltages from power circuits may be recorded directly, without amplification, design may be expanded to provide additional recording channels by increasing the width of the tape and providing additional record heads. A 4-inch tape width should accommodate 12 channels with adequate margin between recorded paths. Continuous recording and erasing would eliminate fast-starting mechanisms but a time-delayed stop mechanism arranged for tripping by certain transients would be required. An endless belt 30 inches in circumference driven at a speed of 6 inches per second would permit preserving up to 5 seconds of power system phenomena including a section of steady-state conditions prior to the transient. This would be equivalent to a 5-foot record from a conventional automatic oscillograph, although conventional automatic oscillograms average about 2 feet in length.

If it is considered essential that the oscillograph be capable of producing a record of unlimited length, or several records in rapid succession, equipment could be arranged to transfer automatically the magnetic impressions from the endless belt to a stand-by supply of magnetic recording material by a rapid "contact printing" process in the presence of a high-frequency field.[5] The fault or transient detector then would operate to engage the transfer apparatus and the endless belt would never be stopped.

One oscillator and amplifier channel should be adequate for any reasonable number of recorded traces. Transcribing of the traces can be performed one at a time, requiring only one pen and ink transcriber and one pickup head. The time required for transcribing 12 traces would be in the order of 2 minutes—less time than required for photographic processing exclusive of washing and drying. Time marking of all traces simultaneously as they are recorded could be accomplished by linking all of the recording heads by a pulsed timing circuit operated by a cam on the tape drive synchronous motor or by an independent timing circuit. Matching of the independently transcribed traces could be effected readily by the timing marks. Automatic and continuous calibration of all traces could be effected by controlling the magnitude of the timing circuit pulses.

The advantages of flexibility in recording and transcribing speeds, the small amount of equipment required for recording a large number of quantities, the facility for recording a period of steady-state conditions prior to a transient, the use of small quantities of low-cost material for recording, the elimination of need for a darkroom and wet photographic processing, and the time saved in obtaining usable records appear to recommend this form of recording, especially for power system automatic oscillography. The large number of traces which can be recorded easily, the flexibility of speeds, and the elimination of the delay and inconvenience of photographic processing represent especially desirable features for field or laboratory oscillographic work. The unique fact that any number of graphical transcriptions may be made from any recording may be found an advantage in either application.

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The Scotch Plaid Raster

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THE MEMORY OF several electronic computers is based on the storage of charges on discrete areas of the inner faces of cathode-ray tubes. The location of these charges is determined by a resistor network, called a deflection generator.

The storage areas, or spots, on the tube face must be so far apart that there is no interference between adjacent areas. Therefore, the designed separation of the spots must include an allowance for variations in the deflection voltages in addition to the minimum necessary to avoid interference when deflections are perfect. Since each resistor of the deflection generator contributes differently to the total deflection, it seems clear that either the quality of the resistors should differ or greater clearance should be allowed on the tube face for deflection variations due to those resistors contributing the greater deflections, or both.

Each counter of the deflection generator switches its resistor to one of two potentials, which may be normalized to one volt and zero volts, according to the counter setting. Let the nominal values of the conductances be g_0, g_1, g_2, . . . g_{n-1}. Let the actual value of the conductance lie between $g_i(1-x_i)$ and $g_i(1+x_i)$, where x_i is the per-unit tolerance of the conductor. The spacing of the spots will depend upon the actual conductance values, not the nominal values.

As the resistors of the deflection generator vary within their tolerance limits, the spaces between the lines of the raster change. Between any pair of lines there will be a minimum separation which depends upon the designed separation and the resistor variations. If the designed separations are equal, then the minima are quite unequal unless resistors of impractical quality are used. Since it is the least of these minima which determines the success or failure of the memory it is much better to make the designed separations nonuniform so that the minima will be equal. This raster, with the nonuniform ideal spacing, the authors have called the Scotch Plaid raster because of its appearance.

Figure 1, using a 4-line raster and conductances of ±20 per cent tolerance, illustrates the difference between a uni-

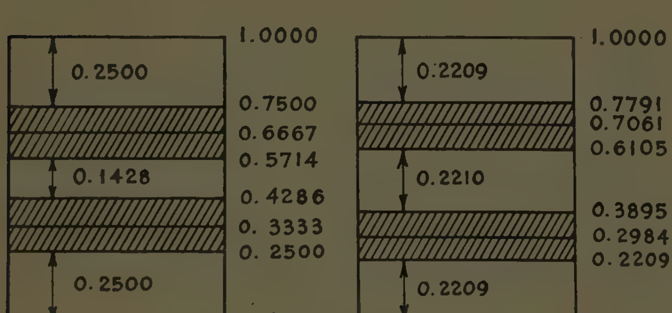

Figure 1. Comparison between a uniform 4-line raster (left) and a 4-line Scotch Plaid raster (right), both with 20 per cent resistors

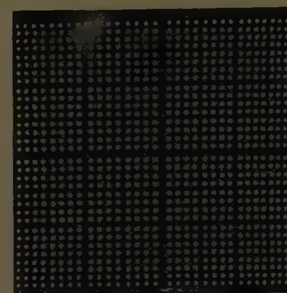

Figure 2. An actual Scotch Plai[d] raster. The halation is due to re[-] flected light. Raster is approxi[-] mately 1½ inches square on th[e] tube face

form and a Scotch Plaid raster. The Scotch Plaid raster i[s] obtained by making $g_1=2.3507g_0$ instead of $g_1=2g_0$ as re[-] quired for the uniform raster. The minimum spacing o[f] this Scotch Plaid raster is 55 per cent greater than the leas[t] of the three minimum spacings of the uniform raster. Thi[s] can be used to reduce the over-all raster size, to increas[e] the resistor tolerances, to increase the margin of safety, o[r] to obtain a combination of these advantages.

In the general case of 2^n lines, or 2^{2n} spots, if the minimum spacing is to be uniform the conductances must be chose[n] so that

$$\frac{g_k}{g_0}=2^k\prod_{1}^{k}\left[\frac{1+sx_{i-1}}{1-x_i+2sx_i}\right] \quad (1$$

where s is the minimum spot separation, expressed as a frac[-] tion of the linear raster size, and x_i is the fractional toler[-] ance of the ith conductor. When all conductors have equa[l] per-unit tolerances, x, equation 1 becomes

$$\frac{g_k}{g_0}=2^k\left(\frac{1+sx}{1-x+2sx}\right)^k \quad (2$$

The Scotch Plaid raster admits the use of much greate[r] resistor tolerances than does the uniform raster and the ad[-] vantage increases with the number of spots. For 1,02[4] spots the ratio is greater than 6.2 and for 4,096 spots th[e] ratio is greater than 10.5. Naturally, in either the unifor[m] or the Scotch Plaid raster, a large resistor tolerance is ob[-] tained at the expense of the spot separation or the raster siz[e] or both, but the Scotch Plaid raster is very much better i[n] this respect than the uniform raster. For example, th[e] linear size of a 4,096-spot Scotch Plaid raster designed for [...] per cent resistors is only 1.36 times that of a raster usin[g] ideal resistors and the same minimum separation. On th[e] other hand, a uniform 4,096-spot raster would have to hav[e] 0.4 per cent resistor if its size were to be only 1.36 time[s] that of the ideal, while it would fail completely with an un[-] fortunate selection of 1.6 per cent resistors—no matter ho[w] large it might be.

Digest of paper 51-276, "The Scotch Plaid Raster," recommended by the AIEE Co[m-] mittee on Computing Devices and approved by the AIEE Technical Program Co[m-] mittee for presentation at the AIEE Summer General Meeting, Toronto, Ontar[io,] Canada, June 25–29, 1951. Scheduled for publication in AIEE *Transactions*, volume 7[0,] 1951.

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High-Voltage Interrupter Switch Applications

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IN RECENT YEARS there has been an increasing demand for air-break switches capable of interrupting load currents, charging currents, and moderate fault currents on highest voltage systems. In answer to this demand an experimental 115-kv interrupter switch was subjected to field tests and designs for 46, 69, and 115 kv were developed and are now in service on many high-voltage systems.

These interrupter switches are essentially 3-pole group-operated air-break switches in which each pole is provided with an oil-blast interrupting contact in series with the switch blade. Figure 1 shows a single pole of a 69-kv switch. The interrupter contact is located in a porcelain tank containing a few gallons of oil. It is actuated through the rotating insulator stack at the right. The operating mechanism of the interrupter switch is identical to that of a conventional air-break switch and, depending on the application, is actuated by a manual control handle, a motor mechanism, or a spring-opened automatic trip mechanism actuated by a d-c trip coil. The switches have a current-

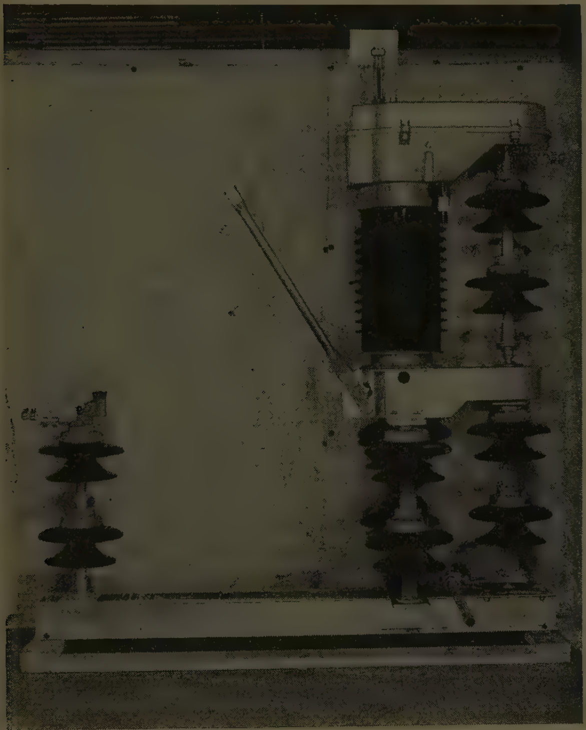

Figure 1. Single-pole unit, 69-kv interrupter switch

carrying capacity of 300 amperes, an interrupting rating of 2,400 amperes, and, when provided with automatic trip, they open in 15 cycles.

One of the most frequent applications of 115-kv switches has been the differential protection of transformer banks. Relays are actuated from the bushing-type current transformers around the high side and low side of transformer

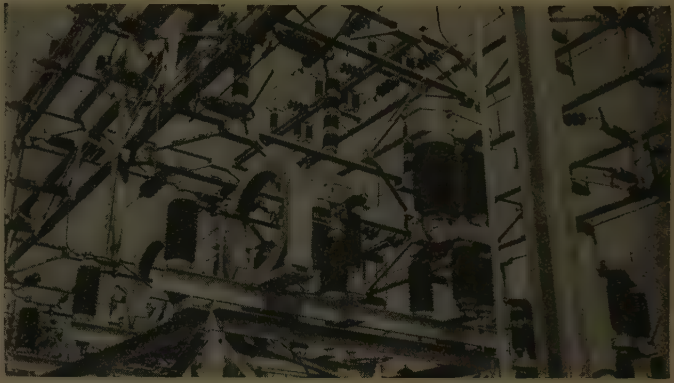

Figure 2. 46-kv interrupter switch installation with air-insulated current transformer

bushings. Contrary to fuse protection, the danger of single-phasing is avoided.

Interrupter switches are suited ideally to interrupt the exciting current of transformer banks. Air-break switches, when used for this purpose, produce numerous restrikes with overvoltages which may damage the transformer insulation. On large banks there is danger of the open arc flashing to ground.

Sectionalizing under load or line dropping can be either manual or by remote control by means of a motor mechanism.

Interrupter switches, not containing bushings, do not lend themselves to the installation of bushing-type current transformers.

Relaying can be accomplished by means of separate current transformers; their cost is not always justified unless metering is to be done at the location.

An inexpensive air-insulated current transformer has been developed for relaying applications, as shown in Figure 2. The transformer is of the through type; a multitap secondary is provided around the core. To obtain tripping at low currents with a minimum core weight, the secondary burden is kept small by the use of low-energy relays. In this manner, tripping current values below 100 amperes are accomplished readily.

Numerous interrupter switches of 46, 69, and 115-kv voltage rating are in service. They give protection superior to that of fuses due to 3-pole operation. In many cases where oil circuit breakers are not economically justified and where fault currents are small, interrupter switches offer economical circuit protection and reclosing operation.

An inexpensive through-type air-insulated current transformer has been developed to provide relay tripping.

Digest of paper 51-315, "High-Voltage Interrupter Switch Applications," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, Portland, Oreg., August 20–23, 1951. Not scheduled for publication in AIEE *Transactions*.

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A 24,000-Kilovar Series Capacitor in a 230-Kv Line

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THE NECESSITY FOR long-distance transmission of electric power has grown rapidly during recent years. Line reactance becomes a problem of increasing importance when transmission distances continue to increase. Long lines cannot be loaded sufficiently for maximum over-all economy because of limitations imposed by transient stability and kilovar requirements.

The most important alternative to reduction in equivalent line impedance by further increase in transmission voltage is the use of line-reactance compensation. Such compensation can best be obtained through the use of capacitors operating in series with the line conductors. To permit the use of series capacitors rated on the basis of normal load conditions, it is necessary to protect them effectively during line-fault conditions. To make maximum use of line-

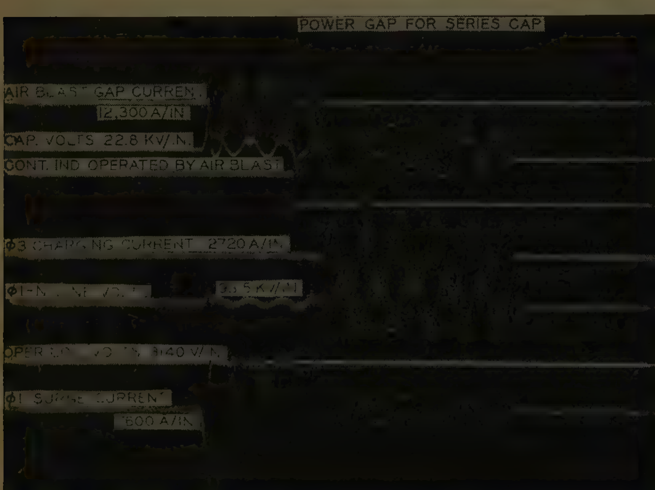

Figure 1. Operation of compressed air power gap used to protect series capacitor

reactance compensation with capacitors it is necessary to by-pass and protect them only during line-fault condition and reinsert them with minimum delay after the line fault is cleared. Lack of means for accomplishing the latter has prevented the use of capacitors for line-reactance compensation where the primary objective is increasing power transmission.

A protective means has been developed now which meets these requirements, and a 24,000-kilovar series capacitor has been installed by the Bonneville Power Administration in a 230-kv line at their Chehalis substation for the purpose of compensating line reactance and increasing the power limits of this line. This is the first installation of this type, and it is the first time a series capacitor has been used in a high-voltage transmission line in the United States.

The protective device not only should protect the series capacitor while the line current is excessive but should re-store it to service at the instant the fault is removed. In th case where the line is re-energized, the protective devic should not function when the line is de-energized, eve though the line is de-energized for only a few cycles. Such protective device permits the use of capacitor units having voltage rating based on the maximum continuous load cu rent, and also permits of a relatively close protection leve This close protection level may be used since the operatio of the protective device does not create risks as to system sta bility. Operation of the protective device takes place onl during the actual periods of excessive currents. It is ex pected that since these requirements have now been m the series capacitor will become a practical means of increa ing the power capacity of existing transmission lines an will permit the use of longer lines.

The first installation of a series capacitor on a transmissio line for the purpose of increasing the transmission of powe is located on the Bonneville Power System at the Chehal substation, and is installed in a 230-kv line leading to th Longview substation. The rating of the initial installatio was as follows: 1. reactance 51 ohms; 2. continuou working current 312 amperes; 3. momentary workin current 468 amperes; 4. fault current 3,200 ampere duration 15-cycle maximum; 5. line voltage 230 kv.

The housings provided additional space for adding capa itor units to bring the reactance to 31.84 ohms, for working current of 500 amperes and a 3-phase kilova rating of 23,800 kilovars.

Each phase of the series capacitor consists of a platfor $12^1/_2$ feet wide and 85 feet long supported on 24 columns insulators and supporting two metal-clad housings eac with space for 288 15-kva 7,960-volt capacitor units. Th air supply tanks, gaps, and resistors are mounted betwee these housings. Air is supplied from the ground through a insulated air line similar in appearance to one of the insu lator columns.

Figure 1 shows an oscillogram of a laboratory test whic illustrates the operation of the compressed air protective d vice. In this test a $3^1/_2$-ohm series capacitor was connecte in a circuit which, when energized, produced a current approximately 4,500 amperes. This current, shown in th bottom trace, was reduced to the normal rated value 1,150 amperes after $3^1/_2$ cycles.

The voltage across the capacitor, second trace from th top, was limited by the breakdown of the gap. The flow gap current, top trace, stopped abruptly when the norm line current was restored.

Digest of paper 51-304, "A 24,000-Kvar Series Capacitor in a 230-Kv Transmiss Line," recommended by the AIEE Committee on Transmission and Distribution a approved by the AIEE Technical Program Committee for presentation at the AI Pacific General Meeting, Portland, Oreg., August 20–23, 1951. Scheduled for pu cation in AIEE *Transactions*, volume 70, 1951.

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Stroboscopic Earth Inductor Compass

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The need for a sensitive, quick-acting, and reliable compass for small aircraft led to the development of this induction compass which utilizes the stroboscopic effect.

NAVIGATION, today, is primarily dependent upon the compass. The simplest of all compasses in use is the magnetic compass, which had its origin around the close of the twelfth century. The Chinese are credited with the invention of this instrument and it was later taken to Italy by the famed adventurer, Marco Polo. The first real improvement over the magnetic compass in almost 450 years was the invention of the gyro compass early in this century. This instrument was proved highly successful for shipboard use, but had definite limitations when used in aerial navigation. It required initial setting from a magnetic compass and frequent resetting in flight, particularly in rough air and after turns.

The Pioneer Gyro Flux Gate Compass was developed by the Bendix Aviation Corporation for the purpose of supplying the aircraft industry with a fast-acting instrument to compensate for the shortcomings of the gyro compass.[1] This instrument, compared with the ordinary magnetic compass, gives a highly accurate indication of direction and does so within relatively close proximity to the earth's magnetic poles. It operates on a null balance principle which causes an instrument deflection to correspond to the direction of the earth's field.[2]

Recently another type of compass, known as the Cathotrol, has been devised which uses a special form of cathode-ray tube. The electron beam in the tube is deflected by the earth's field.[3] This deflection of the beam is transformed into an instrument reading which is an indication of magnetic direction.

Both the Pioneer Flux Gate Compass and the Cathotrol require a quantity of equipment which makes them unsuitable for light plane use from the standpoint of size, weight, and cost. It is the purpose of this article to describe a type of earth inductor compass, recently devised, which embodies the desirable features of both the Pioneer Flux Gate Compass and the Cathotrol with a simplified principle of operation.

In preparation for this article the author attempted the development of a stroboscopic earth inductor compass for use in small craft. The investigation proved that a highly sensitive and quick-acting instrument could be developed which operated on the stroboscopic principle. An experimental compass was constructed which consisted of an indicator and the accompanying electronic circuit. The instrument showed extreme sensitivity even when operated in a building which had a steel roof which acted as a partial magnetic shield. It operated in every position except that in which the flux-sensitive coil was aligned with the dip of the earth's field. All developmental work is not completed, however, as certain mechanical details demand further attention.

Essentially full text of paper awarded Second Best Student Paper Prize for papers presented during the period August 1, 1949, to July 31, 1950.

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PRINCIPLE OF OPERATION

THE DEMONSTRATION model of this instrument consists of the indicator, a high-gain voltage amplifier, and a stroboscope. Magnetic direction is displayed in the form of a stroboscopic indication on a compass scale in the indicator. It is necessary to synchronize the flashing of the stroboscope with the direction of the earth's field in order to obtain a magnetic bearing. This is accomplished by the use of a synchronizing voltage obtained from a coil of wire rotating in the earth's field. Due to physical limitations on coil size and speed of rotation, the induced voltage is on the order of a few millivolts. The voltage amplifier is used to increase the coil voltage to a level suitable for synchronization of the stroboscope. The block diagram of Figure 1 shows the arrangement of the components.

To understand the process of synchronization, the following analysis is helpful. The voltage output of the rotating coil is essentially a pure sine wave due to the uniformity of the earth's field over a small increment of space. The amplitude at any point on the sine wave is dependent upon the position of the coil with respect to the direction of the earth's field as shown in Figure 2. Note that the voltage induced in a coil rotating on a vertical axis is produced entirely by the horizontal component of the earth's field.

When the stroboscopic light, which is synchronized to the induced sine wave, is allowed to fall on the rotating coil, it appears to stand still. Its stopped position in space will depend upon the point on the sine wave at which synchronization is effected.

In order that the compass show a bearing which is

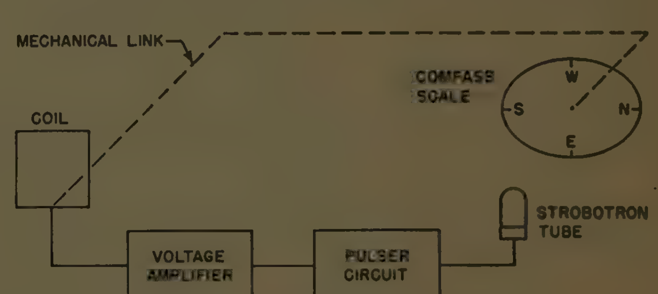

Figure 1. Block diagram showing the arrangement of components of the compass

independent of the amplitude of the synchronizing voltage, some fixed synchronization point must be maintained. The most convenient point on the sine wave to effect synchronization is in the increment of greatest slope which is the zero intercept of the sine wave. Upon successive amplification, clipping, and pulsing, the zero intercept of the sine wave appears as a steep leading edge of a positive pulse. The waveforms of Figure 3 show the successive distortions which must be performed on the sine wave to obtain the desirable synchronizing signal.

The necessary clipping of the sine wave is accomplished in the amplifier itself. The first two stages of the amplifier operate as a conventional amplifier providing a signal of sufficient amplitude to overdrive the third amplifier stage. Clipping occurs in the input to this stage, which results in a square wave at the output. The leading edge of the square wave is used to trigger the stroboscope pulser circuit which, in turn, initiates the flashing of the strobotron tube. The light from the tube then is directed toward the compass scale which rotates on the same shaft as the coil. Under the stroboscopic light, the numbers on the compass scale appear to remain stationary. By the use of a hairline placed over the compass scale, a magnetic direction may be determined. The error present in the indication is dependent upon the change in slope of the leading edge of the synchronizing pulse and also upon the change in phase shift which occurs within the voltage amplifier. To minimize the error in the system, a high-gain amplifier must be used having negligible change in phase shift over the operating range.

Thus it may be seen that the direction of the earth's field is effective in causing synchronization of the stroboscope which points out a magnetic direction on the scale.

DEVELOPMENT AND ANALYSIS OF COMPONENTS

The Indicator. The indicator consists of a compass scale and a hairline upon which the stroboscopic light is directed. For the sake of mechanical simplicity, the rotating coil is incorporated within the indicator itself; however, it may be isolated from the indicator. The relative angle between north on the compass scale and the plane of the coil must be 90 degrees, as in Figure 2.

The coil consists of 1,000 turns of number 40 enameled

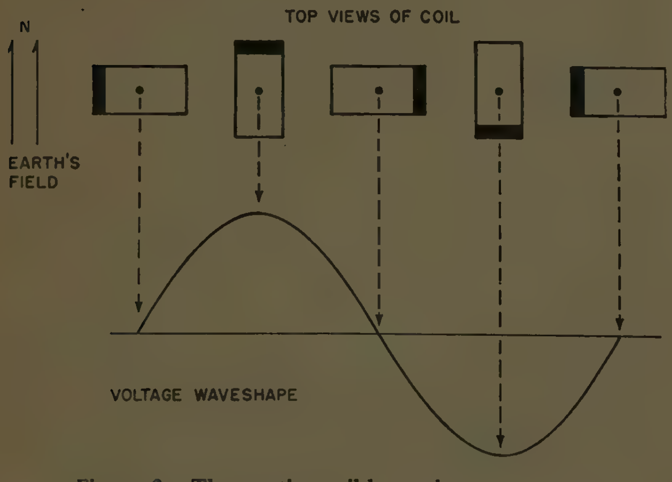

Figure 2. The rotating coil has a sine-wave output

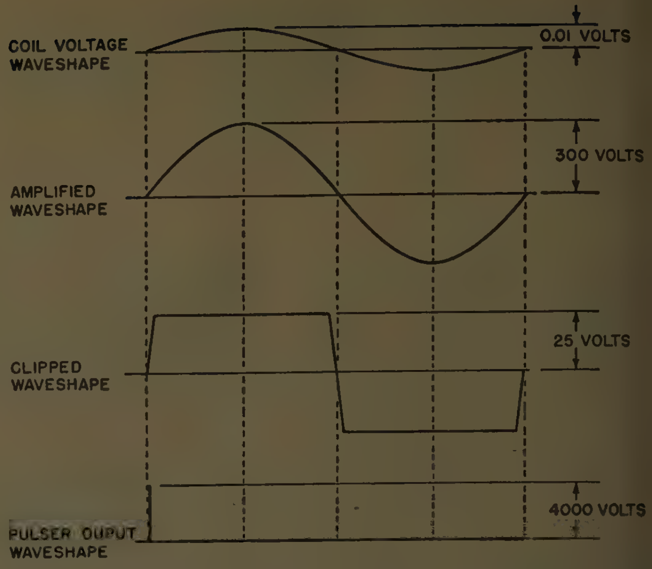

Figure 3. Successive steps in obtaining the synchronizing signa

wire placed on a wooden loop having 2 square inches o area. At each end of the coil is placed a small aluminun plate containing a tapered hole. These plates serve twofold purpose. First, they act as bearings into whicl tapered points are placed, thus supporting the coil Second, the coil leads are fastened to these plates so tha they act as rotating contactors for sampling of the generate voltage. The tapered points which fit into the tapere holes on the plates are connected to the amplifier inpu cable. These points may be adjusted for proper bearin pressure and then locked securely. Early tests showed thes rotating contacts caused a large amount of noise in th output voltage. This was overcome by placing graphite i the bearings and then adjusting until the coil would barel rotate freely.

A transparent compass scale was bolted to one of th plates in the position such that north was 90 degrees awa from the plane of the loop. Slots may be placed in th compass scale so that the 90-degree angle may be change slightly for calibration purposes. As any size electri motor operating near the coil would cause distortion of th earth's field, the coil was rotated by a stream of air directe at the coil sides. This required more air than could b supplied continuously by the small compressor which wa available in the laboratory. A small turbine was trie next and proved to be very effective on a comparativel small quantity of air. The turbine blades were smal blocks of plastic placed directly around the inner are of the compass scale. A nozzle, formed from a smal diameter copper pipe, directed the air at the turbine blade At a speed of 3,600 rpm the voltage output was 0.01 volt.

It was observed in the first arrangement that the strobo scopic light source could not be mounted close to the coi because of the feedback effect which results. Due to th proximity of the compass scale and the coil, it was necessar to keep the light source at a distance from the indicato Sufficient illumination was obtained when the light wa directed on the compass scale from about two feet.

Through the use of a different arrangement of the com ponents, the light source may be placed directly beneat

he compass scale. This would necessitate isolation of the oil from the compass scale by a flexible shaft.

The Amplifier. A high-gain audio amplifier was used n all the experimental tests. With the gain set at 30,000, n input voltage of 0.01 volt resulted in a square wave utput having a peak value of 25 volts. With the coil urning at the normal operating speed of 3,600 rpm, the otal correction in the indication is 9.9 degrees. This orrection is constant at a constant speed and may be emoved from the indication by rotating the compass cale with respect to the coil through the desired angle. The only error introduced in the indication is caused by the oil speed deviating from the normal speed. However, his error amounts to only 2.97 degrees when the coil peed is increased 50 per cent. The error may be eliminated by using a small governor to keep the coil speed onstant.

Experimentation with amplifier circuits with inadequate hielding resulted in oscillations produced from feedback rom the light source. Amplifiers operating from 60-cycle ower supplies were tried with the result that the indication was erratic. This was probably due to 60-cycle pickup n the amplifier beating with the input frequency, causing he numbers to oscillate slightly.

The Stroboscope. The first source of stroboscopic light which was tried was a neon bulb coupled to the output of a triode pulse circuit delivering a 100-volt pulse. Because of the very short pulse width, the light output was too small for adequate illumination. Therefore, it was decided to use a high-voltage pulser circuit to get sufficient illumination from the neon bulb. This arrangement worked satisfactorily for about an hour with a new neon bulb, after which time the neon bulb blackened on the inside due to the excessive exciting voltage. A cathode-ray tube also was investigated for possible use as a light source, but was soon discarded due to the persistence of the screen. The light source finally employed in the instrument was a high-voltage trigger strobotron. The light flash has a duration between 5 and 10 microseconds, which is well below the time necessary to produce a blurred indication operating at normal speed. The strobotron circuit is shown in Figure 4.

The pulse required to trigger the strobotron is in excess of 4 kv. This pulse may be obtained from a thyratron pulser circuit as shown in Figure 5.

The operation of the circuit may be explained as follows. The type-*2050* thyratron is held well below cutoff by a 20-volt bias applied to the control grid. During the cutoff time, the capacitor *C* charges to the supply voltage through the pulse transformer primary and resistor *R*. Upon

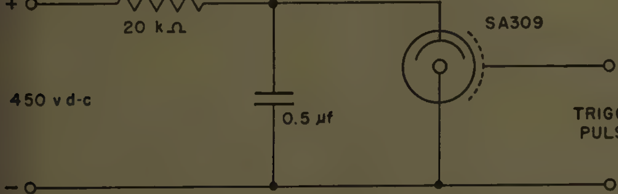

Figure 4. Circuit of the high-voltage trigger strobotron

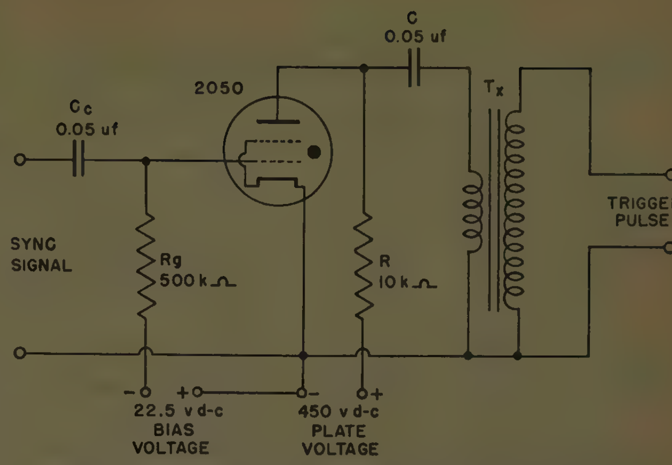

Figure 5. Thyratron circuit for obtaining pulsing trigger

applying a positive pulse of sufficient magnitude to the control grid, the thyratron ionizes and causes capacitor *C* to discharge through the transformer primary. As the ionization time of the thyratron is very small, the current change through the primary winding is very rapid, causing a high-voltage pulse to be induced in the secondary through the step-up transformer. This pulse is applied to the strobotron trigger electrode for initiating the flash of light. When capacitor *C* discharges to a low value of voltage, ionization can no longer be sustained in the thyratron. Therefore, the thyratron deionizes and the circuit is ready for recycling.

FUTURE DEVELOPMENT

THE APPLICATION of this instrument to light planes depends upon slight modifications of the coil and the associated circuit. By replacing the high-voltage trigger strobotron with a grid-controlled strobotron, the requirements of the power supply, as well as the pulsing circuit, may be reduced considerably. The amplifier then would consist of two miniature dual triodes connected as three amplifier-clippers and one pulse amplifier.

The coil would be isolated from the indicator by a flexible shaft. The power necessary for rotating the coil could be obtained from an isolated electric motor or the air stream. By mounting the coil on the wing of the plane, the instrument would be less affected by local magnetic disturbances.

The indicator then would consist of a small compass scale and the light source mounted in a small case directly on the instrument panel. It would be connected to the coil by a flexible shaft and to the amplifier by a small 2-conductor shielded cable.

The amount of equipment required for the instrument is small indeed when compared with the other types of electronic compasses. It is expected that further development will perfect this instrument for light plane navigation.

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Vibracode System of Supervisory Control o[n] a Carrier Communication Channel

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MEMBER AIEE

JOEL DANIEL

Besides providing a high-grade 2-way telephone circuit, this carrier current system used by the Georgia Power Company transmits control signals for operating voltage regulator and capacitor switches, alarm signals when oil circuit breakers trip or tap-changing-under-load transformers get out of step, and telemetered voltage signals.

A COMBINED supervisory control and communication system has been in service on the Georgia Power Company's system for about a year. The Vibracode system was selected after study of several proposals of "package units" which were designed to meet the requirements of the particular problem at hand.

Plant Arkwright, a 160,000-kw steam plant near Macon, Ga., is the principal generating source for the eastern part of the Georgia Power Company system (see Figure 1). This plant is connected through substations at Gordon, Dublin, South Macon, Eastman, and Vidalia to an interconnection with the Savannah Electric and Power Company, and to Brunswick where 5,500 kw generating capacity is available. The power flowing 95 miles from Plant Arkwright into Vidalia Substation has exceeded 60,000 kva, and approximately 18,000 kva goes toward Brunswick another 100 miles away.

To provide proper voltage it was necessary to install a 75,000-kva 110-kv voltage regulating transformer at Vidalia and three 2,250-k[va] banks of capacitors (see F[ig]ure 2). The substation at [Vi]dalia also supplies the 44-[kv] transmission system throu[gh] a 20,000-kva tap-changi[ng]-under-load transformer ba[nk] and a 7,500-kva 44/4-kv su[b]station to which the th[ree] 2,250-kva capacitor banks [are] connected. Automatic voltage control of the capacito[rs,] 110/44-kv transformers, and the 110-kv regulator was [] practical; however, it was necessary to co-ordinate [the] operation of the capacitors and regulators to provide pro[per] voltage for each of the 4-kv, 44-kv, and 110-kv systems.

South Macon is the trouble dispatching center for [the] transmission system and the only full-time attended su[b]station in the area. There is a private telephone circ[uit] between Macon and Vidalia, but an automatic exchange [at] Dublin and the heavy load on this circuit made it unsuita[ble] for direct control of the equipment at Vidalia; so it w[as] decided to install a system suitable to control the 110-

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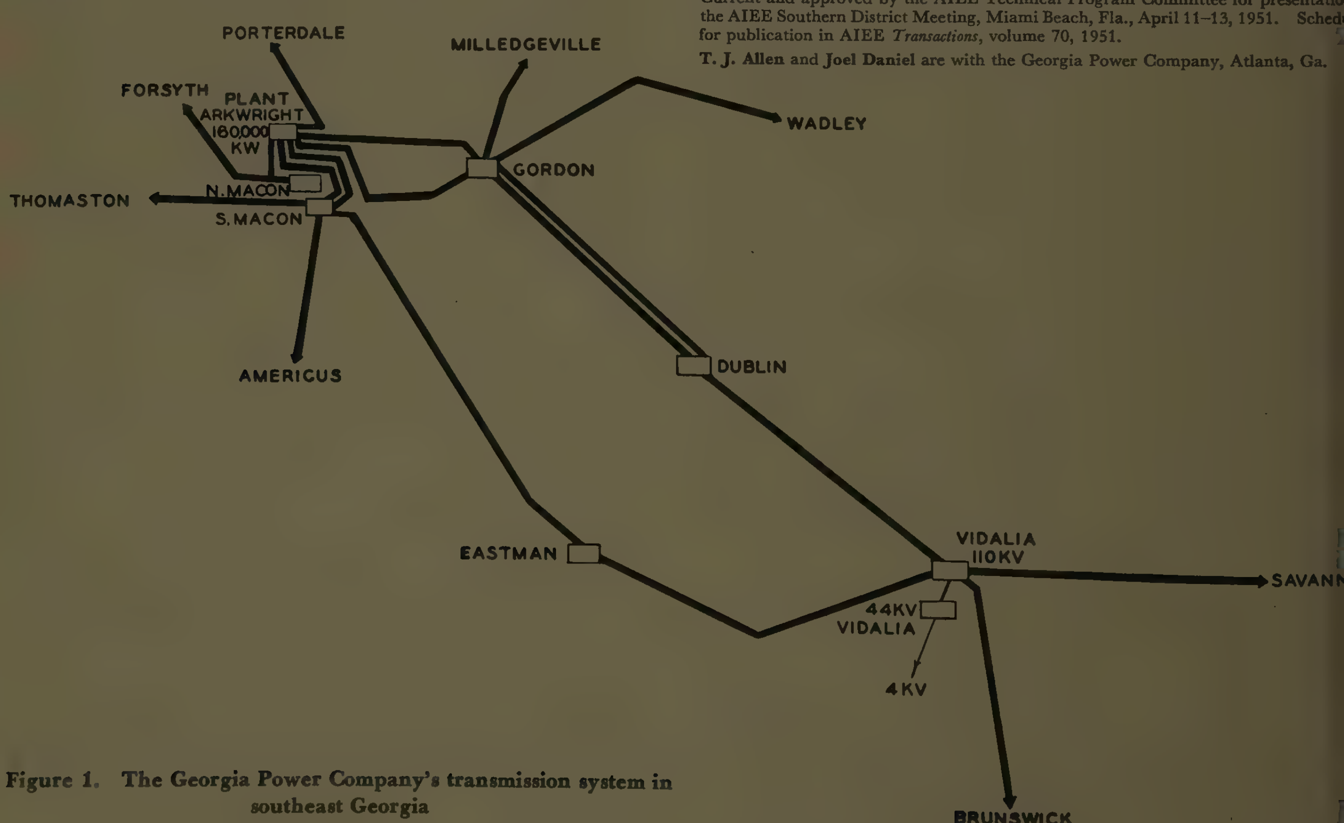


Figure 1. The Georgia Power Company's transmission system in southeast Georgia

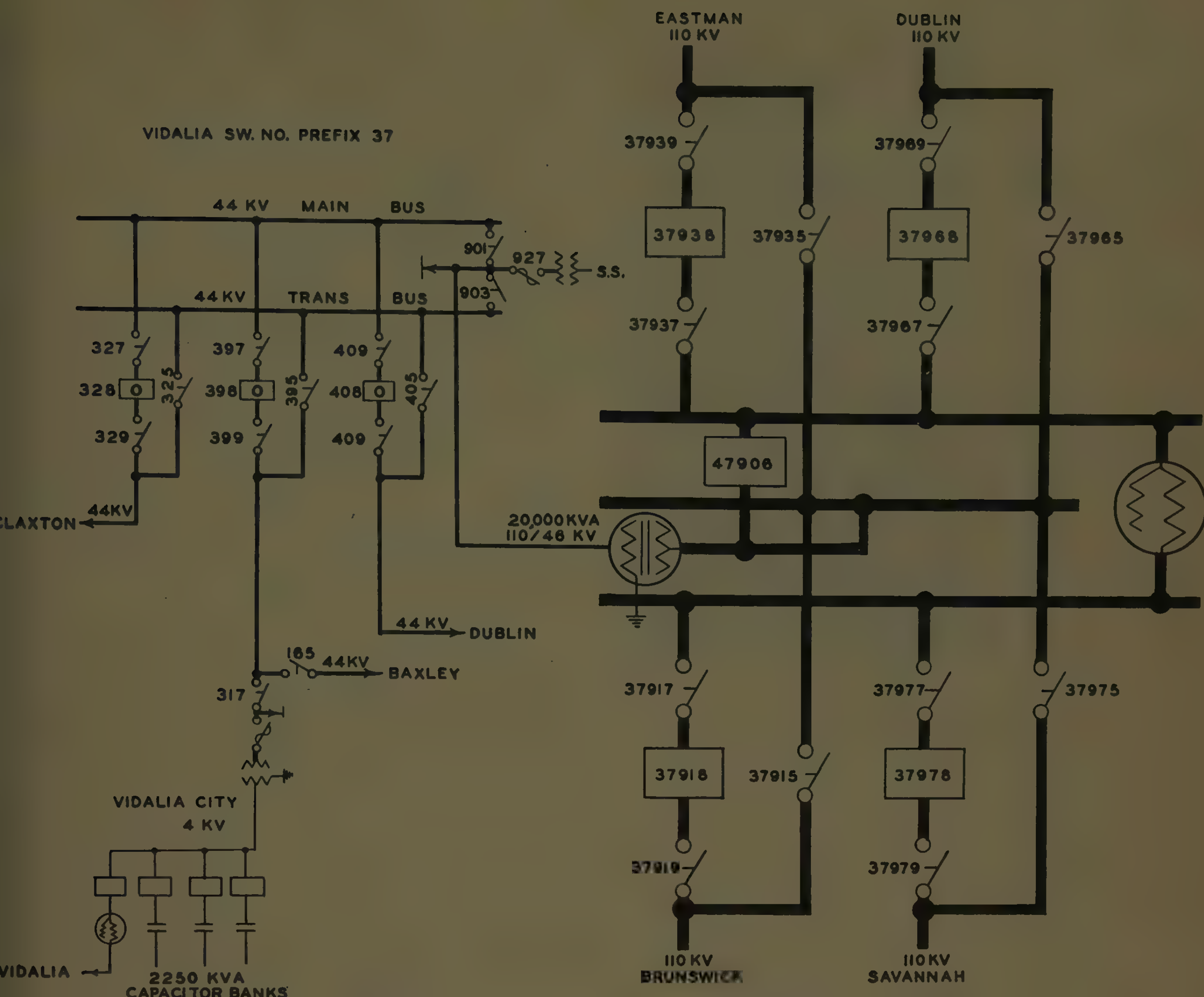


Figure 2. One-line diagram of the Vidalia substation circuit. Power flowing into this station has exceeded 60,000 kva

egulator and three capacitor banks from South Macon and o make the 110/44-kv transformers automatic voltage ontrol.

Carrier-current equipment was specified to procure an dditional communication circuit to Vidalia. The exosed telephone circuit was chosen as the transmitting nedium because of simplified line coupling and trapping.

APPLICATION

THE EQUIPMENT selected had to fulfill the following requirements:

1. Operate by carrier-current in the 50–100-kc band sing the 95-mile exposed telephone line between Macon nd Vidalia as the transmitting medium.

2. Provide a high-grade 2-way communication channel etween Macon and Vidalia capable of being connected nto telephone switching turrets at each end.

3. Be capable of operating the 75,000-kva 110-kv reguating transformer located at the Vidalia 110-kv substation rom the South Macon substation.

4. Operate indicating lights at South Macon substation giving a continuous indication of which tap the Vidalia regulating transformer is on.

5. Provide at South Macon a recorded telemetered voltage from the load side of the Vidalia regulating transformer.

6. Include alarm indications at South Macon giving an audible and visual signal when any of the 110-kv or 44-kv oil circuit breakers at Vidalia trip and when the three single-phase 110- to 44-kv tap-changing-under-load transformers get out of step.

7. Provide for connecting and disconnecting (one at a time) the three 2,250-kva power factor corrective capacitor banks to the 4-kv bus at the Vidalia 44- to 4-kv substation.

8. Transfer the Vidalia telemeter transmitter from the 110-kv bus voltage to the 4-kv bus voltage.

The carrier equipment consists of a terminal containing a transmitter, a receiver, a line coupling unit, and a signalling and telephone termination, installed at South Macon and Vidalia. Carrier frequencies of 55 kc at South Macon and 95 kc at Vidalia were used for the transmitters—the receiver at each location being on the opposite frequency.

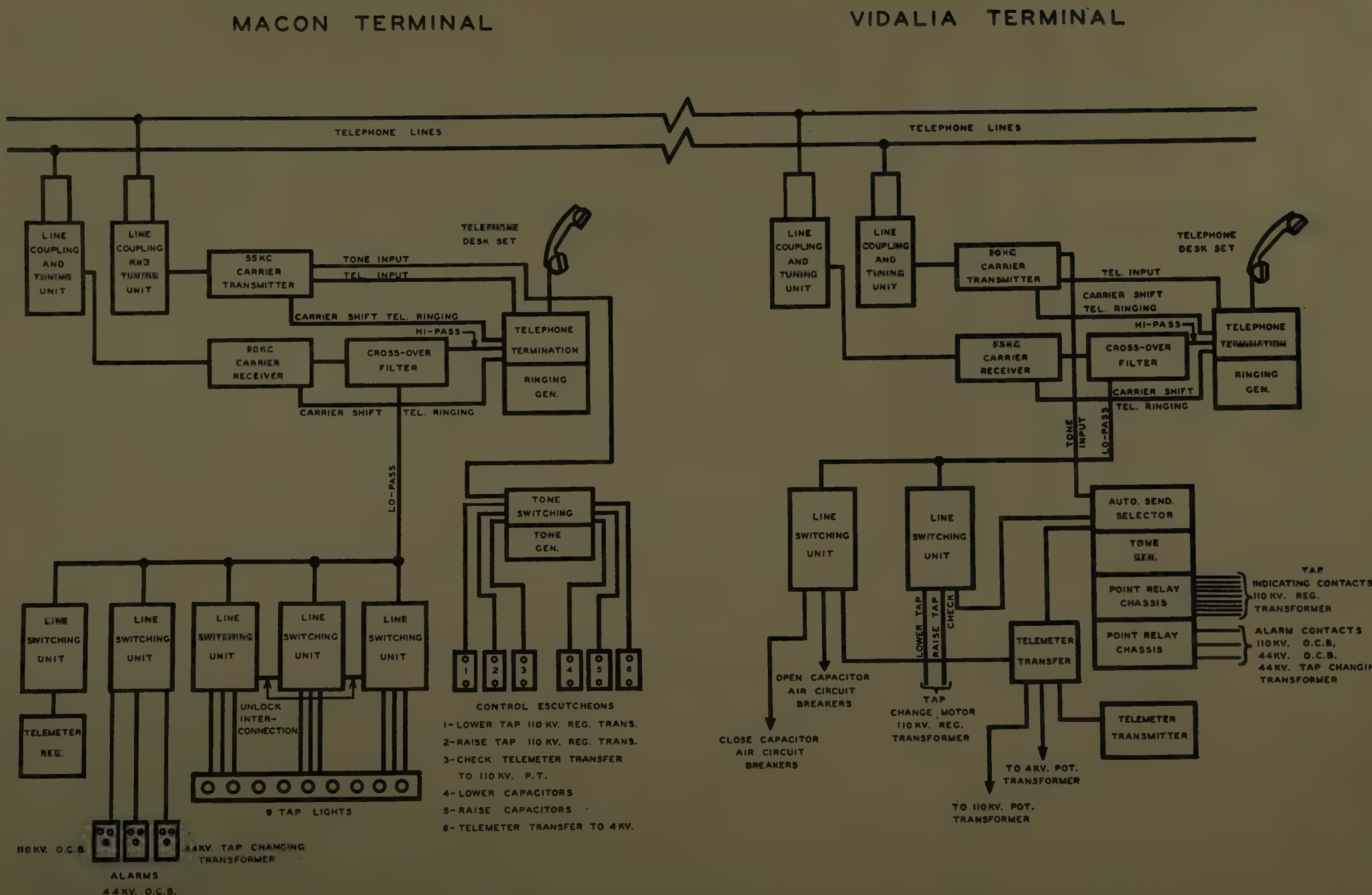


Figure 3. A block diagram of the Vibracode supervisory control and communication system used by the Georgia Power Company

block diagram of the units composing the system is hown in Figure 3. The South Macon and Vidalia termi-als are shown in Figures 4 and 5.

The carrier-current transmitter is a narrow-band fre-uency-modulated unit designed to operate on a specific equency with a power output of 10 watts. It incorporates fast-acting automatic modulation control whereby the arrier deviation, due to modulation, is held to a maximum f 2.5 kc. A 2,500-cycle low-pass filter prevents modula-ion by frequencies outside of the channel. Modulation akes place at a frequency of 455 kc by action of a balanced eactance modulator on a stable oscillator. This 455-kc ignal is mixed with a crystal oscillator to produce a fre-uency-modulated signal at the carrier frequency.

The carrier-current receiver is a narrow-band frequency-odulation superheterodyne unit designed to operate on a pecific frequency. The receiver produces a constant audio utput for signals varying from 300 microvolts to as high as 0 volts. The frequency response is flat over a bandwidth f ±3 kc, while at ±7.5 kc the response is down 100 ecibels. The receiver employs a crystal-controlled local scillator for maximum stability. The audio output is 1 vatt with a 2.5-kc deviation of the carrier frequency.

A 15-kv 0.006-microfarad capacitor is used to couple the arrier equipment to the exposed telephone line which is onstructed on the transmission-line structures. The tun-ng unit matches the transmitter and receiver impedances the line impedance.

Signalling on the communication circuit is accomplished y shifting the transmitter frequency approximately 1 kc. he telephone termination is designed to permit use of a 2-ire magneto telephone circuit in duplex transmitter-eceiver operation and to provide control circuits for tele-hone ringing purposes. The balancing networks are adjusted so that the circuit may be extended through the telephone switching turrets.

Figure 5. The Vidalia substation remote control equipment. This is an outdoor cabinet and contains (from top to bottom) supervisory control equipment, telemeter transmitting equipment, telephone voice terminal, and carrier receiver and transmitter

Built into the transmitter and receiver sections are filters whereby the audio channel is separated into two parts. The first 500 cycles is cut out of the communication channel for supervisory signal tones. This leaves the communication channel operating between 500 and 2,500 cycles with no noticeable impairment in speech quality.

Figure 4. The South Macon substation control station for remote operation of tap-changing transformer. This cabinet contains supervisory control equipment, telephone terminal, carrier transmitter and receiver, and telemeter receiving equipment

SUPERVISORY CONTROL EQUIPMENT

THE EQUIPMENT uses audio-frequency tones to provide the control, supervision, telemetering, and alarm signals. The signals are transmitted and received by the frequency-modulation carrier equipment.

The particular tone system used is known as the Vibracode system. The tone source in this system is the Vibrasender which is essentially a driven tuning fork. It is packaged as a small plug-in unit 1 by 2 by 4 inches and is completely enclosed. A well-regulated power supply, together with a controlled level of oscillation, keeps the output at a constant level and free of harmonics. The Vibrasenders maintain the tone frequency within ±0.15 per cent, which includes original setting error and temperature effects from −20 to +80 degrees centigrade. The frequencies of the tones used in this system are 100.0, 110.9, 123.0, 136.5, 154.1, 167.9, 186.2, 206.5, 229.1, 254.1, 281.8, and 312.6 cycles. The tone responsive element in this system is the Vibrasponder, and it is essentially a resonant reed relay. When voltage of the resonant frequency is applied, the reed vibrates readily. The amplitude builds up quickly and reaches the point where a small contact wire on the reed makes contact with a contact screw. This closes a circuit to change the bias on a vacuum tube and operate a relay in its plate circuit. The Vibrasponder is packaged in a small 7/8 by 7/8 by 3 $^3/_{16}$-inch plug-in unit.

The Vibrasponder maintains its frequency stability within ±0.25 per cent from −20 to +80 degrees centigrade. It has a response curve equivalent to that of a single tuned circuit having a Q of 110. With the basic frequencies being placed approximately 10 per cent apart, the Vibrasponder has 25 decibels of selectivity between adjacent channels.

This Vibracode system performs the various supervisory functions by the selection of two audio tones sent simultaneously. These tones are transmitted over the carrier system, being separated from the communication channel by the system of filters which removes the first 500 cycles of the audio channel for use by the supervisory control audio tones. The control function is started by pressing the button on the proper control escutcheon at South Macon. A pilot light on the escutcheon gives evidence that the signal is being transmitted. The control button through an auxiliary relay in the "tone switching panel" selects two tones from the tone generators and feeds them into the tone input of the carrier transmitter where they modulate the transmitter. The tone-switching panel contains an adjustable timing device whereby the time interval of the tone pulse is held to slightly less than 1 second.

At Vidalia the tone-modulated carrier wave is received and demodulated by the carrier receiver. The output of the receiver is fed into a "crossover filter panel." This filter panel separates the output into two frequency bands. These frequencies from 0 to 500 cycles are passed into the "line switching unit," and frequencies from 500 to 2,500 cycles go from the crossover filter into the telephone termination. The supervisory control tones, being below 500 cycles, are impressed on the input to the line switching units, which are parallel-connected. Each circuit through the line-switching units to a control relay, in effect, has two Vibrasponders in series. In order for the control relay to be operated, the proper frequencies to which the Vibra sponders are tuned must be impressed upon them. Th Vibrasponders change the bias on a tube to operate the con trol relay which is in its plate circuit. The control rela in most instances operates an auxiliary relay which actuall performs the desired function. There are six contr escutcheons at South Macon which provide for six separat control functions at Vidalia. These control functions ar raise the tap setting on 110-kv regulating transforme lower the tap setting on 110-kv regulating transforme check on Macon indications, raise capacitors (adds mo capacitors on 4-kv bus), lower capacitors (disconnec capacitors from 4-kv bus), and telemeter transfer (switch telemeter transmitter from 110-kv bus to 4-kv bus).

At Vidalia all the return supervisory signals, consisting pairs of tones, are initiated by an automatic-send selecto This selector contains a 52-point stepping switch which automatically started whenever a control relay is operate in any of the line-switching units, whenever the check bu ton is pressed at South Macon, or whenever there is change on any of the alarm indications necessary. Th automatic-send selector sends out the pairs of audio ton from Vibrasenders at Vidalia for all indications to Sout Macon in a time interval of approximately 10 second The tones on reception at South Macon operate the prop Vibrasponders and energize the lights on the panel b operation of the control relays in the various line-switchin units.

Telemetering from Vidalia is accomplished by means of Bristol metameter transmitter keying one of the Vibr sender tones at Vidalia which, upon reception at Sou Macon, operates the control relay in the line-switching un to supply pulses to the receiving meter. This is the on function which operates on a single audio tone. The teler eter transmitter at Vidalia is arranged so that it can switched from the 110-kv bus to the 4-kv as desired fro South Macon.

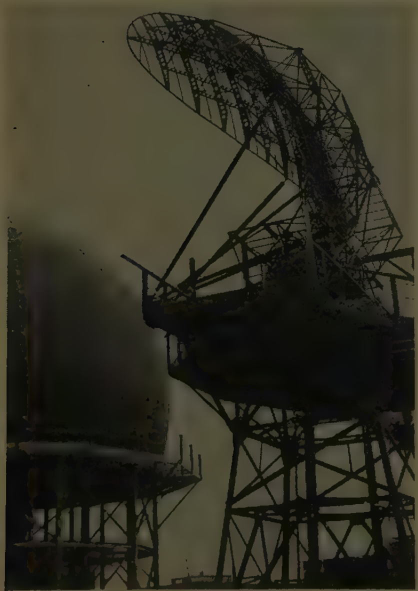
CONCLUSION

There are numerous installations of carrier equipme for supervisory control, communication, and tel metering services. These services in most instances ha been accomplished by the use of separate carrier tran mitting and receiving equipments operating in differe frequencies for each service. This system is different that the same carrier transmitting and receiving equi ments operating on one pair of frequencies are used for three services. This is an economical use of the carri frequencies, as well as being a lower cost installation to do complete job.

Experience to date with this system has been favorab The troubles encountered have been mainly relay adju ments. Relay contacts which operate at infrequent inte vals must be adjusted with considerably greater wiping a tion than those which have a greater frequency of oper tion. Other troubles have been vacuum-tube failures a telephone line troubles.

The communication circuit is excellent. Only the m trained observer can notice that the first 500 cycles missing from the audio frequencies.

Radome Guards Radar Equipment



The balloon-like object is a radome used for protecting radar equipment from the elements. Inside the Arctic Bubble, as it is called, is a rotating radar antenna similar to the one pictured at the right. The bubble, which is supported by internal air pressure, is transparent to the microwave radar signals transmitted and received by the radar antenna although it is opaque to light. This photograph was taken at the Bendix Aviation Corporation, at Baltimore, Md.

The Effects of High-Resistivity Dust in Electrostatic Precipitation

G. W. PENNEY
FELLOW AIEE

In electrostatic precipitation of high-resistivity dust, the voltage drop across the collected layer of dust on the large electrodes may be high enough to cause electrical breakdown. This and other troubles usually can be eliminated by operating at a higher relative humidity or by liberal use of adhesives.

IN ELECTROSTATIC precipitation it is obvious that a dust of high electric conductivity may give trouble due to excessive electrical leakage through a layer of onducting dust on insulators. It may not be as obvious at high-resistivity dust can cause very serious trouble nd is in fact much more kely to cause trouble under ypical operating conditions. The resistivity of most dusts n general will be high only hen the relative humidity is w. At times of low huidity a trouble frequently ccurs called "reverse-ionizaon" or "back-ionization." his results in low efficiency, evere vibration of ionizing wires, and excessive ozone eneration.

The trouble occurs in all types of precipitators but this rticle is restricted to the condition in low-voltage 2-stage recipitators having a positive ionizing wire and used for ir conditioning.

CHARACTERISTICS OF REVERSE-IONIZATION

IN THE NORMAL operation of an ionizer the ions are generated in a small region immediately surrounding the onizing wire. If the wire is positive, as in electrostatic recipitators designed for air-conditioning applications, the lectrons or negative ions are collected immediately by he wire, while the positive ions travel away from the wire, o the large negative electrode. In passing through the ir some of these positive ions are collected by suspended lust particles. The amount of charge which a particle an obtain depends on the voltage gradient, the density f ions, and the time of charging.[1,2] A typical 1-micron article may acquire a few hundred elementary charges, nd a 10-micron particle a few tens of thousands of elenentary charges.

During operation a layer of dust accumulates on the arge electrode of the ionizer. The ions formed at the vire pass through the air to the large electrode and contitute a current which must be conducted through the lust layer. If the resistivity of the dust is increased the esulting voltage drop across the dust increases and the onizing current decreases until the dust layer breaks down electrically. This breakdown tends to occur at points leaving local regions of high voltage gradient at the surface of the dust. This causes a glow discharge or corona which, if viewed in a darkened room, appears as minute glowing spots. A glow at the large or negative electrode provides a source of negative ions which move toward the wire partially neutralizing the effect of the positive ions from the wire. This condition is called "reverse-ionization." With increasing resistivity of the dust the number of glowing spots on the negative electrode increases until at times the entire area appears to glow. The negative ions tend to neutralize the normal positive charge on the dust particles leaving the ionizer. This tends to increase the ionizer current, decrease efficiency, and cause other troubles.

The conditions under which this trouble called reverse-ionization occurs can be predicted if the electrical characteristics of the dust are known. The resistivity of the dust as measured in bulk, multiplied by the current density (ionizer current per unit area), gives the voltage gradient. If this voltage gradient is greater than that needed to produce breakdown, reverse-ionization is to be expected. As an example, a dust having a resistivity of 3×10^{10} ohm-centimeters will be considered. A typical current density is 0.5×10^{-6} ampere per square centimeter. This current density multiplied by the resistivity gives a voltage gradient of 1.5×10^{4} volts per centimeter. Many samples of dust, when subjected to a voltage test, will break down below this voltage gradient.

In estimating the condition at which reverse-ionization will occur, the resistivity of the dust and the electrical breakdown voltage are primary factors. The uniformity of the dust deposit is also important. The resistivity of collected dusts may vary from a fraction of an ohm-centimeter to 10^{13} ohm-centimeters or even higher. The breakdown voltage varies through a much smaller range. General experience seems to indicate that reverse-ionization is probable if the resistivity of the dust is greater than 10^{11} ohm-centimeters and is improbable if the resistivity of the dust is less than 5×10^{9} ohm-centimeters.

TESTS OF HIGH-RESISTIVITY DUST

TO STUDY THE effect of high-resistivity dust and the nature of reverse-ionization a series of tests was made using electrically precipitated fly ash. The sample used

ull text of paper 51-201, "Electrostatic Precipitation of High-Resistivity Dust," ecommended by the AIEE Committee on Electronics and approved by the AIEE echnical Program Committee for presentation at the AIEE Summer General Meeting, oronto, Ontario, Canada, June 25–29, 1951. Scheduled for publication in AIEE *ransactions*, volume 70, 1951.

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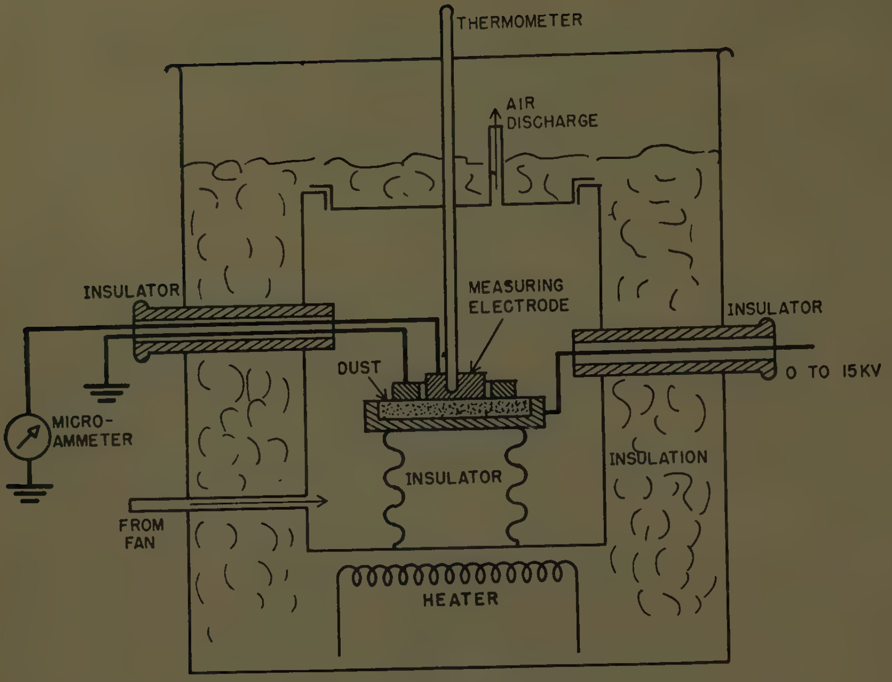


Figure 1. Cross section of apparatus used for measuring resistivity

was taken from a power plant burning a type of coal under conditions which were known to give trouble in electrostatic precipitation. This was a convenient way to get a large homogeneous sample of a dust. It is of course a material which frequently is discharged into the atmosphere and must be removed by air cleaning devices. The sample used was chosen because it had an unusually high resistivity at moderately low humidities. It was therefore a good sample to demonstrate trouble, but it should not be regarded as a typical dust.

In an agglomeration of particles such as a layer of collected dust, the resistivity as measured on a large sample depends largely on the surface resistivity of the separate particles and so it is to be expected that the resistivity as measured will depend on the humidity. Tests were made in which a sample of dust was placed in a test cup with a measuring electrode surrounded by a guard electrode resting on the dust. The temperature and dew point of the air surrounding the sample could be controlled. Potentials from 0 to 15,000 volts could be applied across the sample and the current measured. Figure 1 is a sketch of the apparatus. A fan was used to circulate air slowly through the test oven. The relative humidity was varied by controlling the temperature of the sample. To get a high dew point, a few tests were made in which the ingoing air was bubbled through water. The temperature of the air surrounding the sample was held constant for approximately two hours before taking readings. This seemed to give equilibrium conditions. The measuring electrode was 2 inches in diameter and the sample of dust 9/32 inch thick. For resistivities less than 5×10^{10} ohm-centimeters the current could be read with a microammeter. For higher resistivities a galvanometer was used to measure the current. The pressure on the sample was approximately 4.75 grams per square centimeter. Under these conditions the resistivity measured is a function of dew point, temperature, packing, and applied voltage. Tests were made in which the dew point varied from 35 degrees Fahrenheit to 80 degrees Fahrenheit. In Figure 2 the resistivities measured are plotted as a function of relative humidity. The curve shown is for 3,000 volts across the sample, giving a voltage gradient of 4,200 volts per centimeter. At 2,800 volts per centimeter the resistivity is approximately 18 per cent higher and for 5,600 volts per centimeter about 10 per cent lower.

To study the effect of a layer of dust on the ionizing current the large electrodes of the precipitator cell shown in Figure 4*A* were coated by slowly blowing dust into a ce

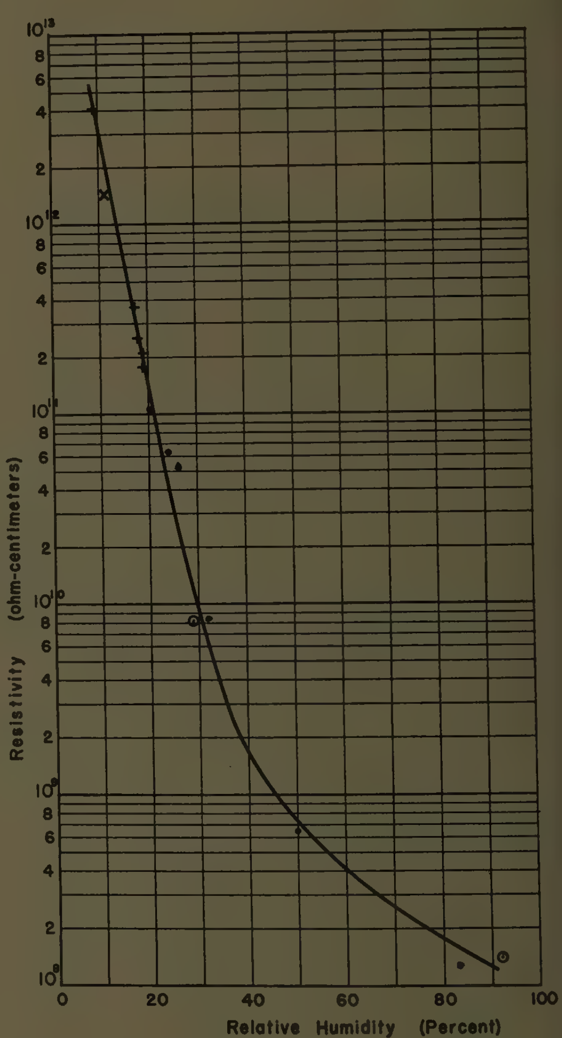
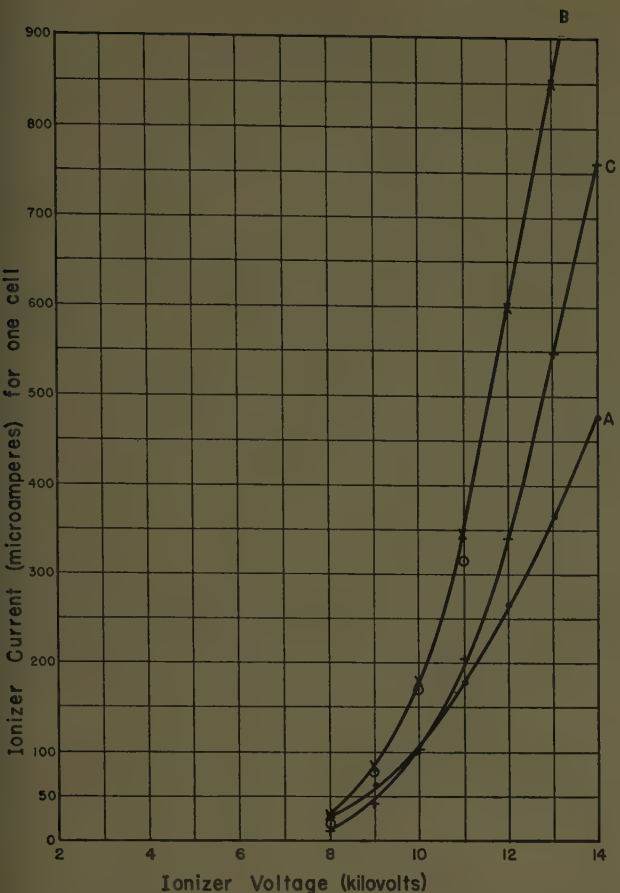


Figure 2. Resistivity of fly ash used for tests. + indicates point between 35 and 40 degrees Fahrenheit; × indicates point between 40 and 45 degrees; · indicates dew point between 45 and 50 degrees; and ⊙ indicates dew point a degrees



igure 3. Ionizer current of one cell. The large electrodes of he ionizer were coated with fly ash. (A) 80 degrees Fahrenheit t 60 per cent relative humidity; (B) 149 degrees at 9 per cent; (C) 106 degrees at 32 per cent

ith the ionizer energized until the dust layer reached thickness of about 1/32 inch. The cell then was mounted n insulators in a box in which the temperature could be ontrolled. The dew point in the box remained constant t 65 degrees Fahrenheit. The box was heated to 176 egrees Fahrenheit over a period of 4 hours and then ooled slowly.

During the entire cooling interval curves of current ersus voltage were taken. These curves are shown in igure 3 together with a curve for a clean cell. Curve A or the clean cell was essentially the same as a curve for he electrodes coated with dust and tested at 60 per cent elative humidity. It has been found that the rate o ooling used to obtain curves B and C of Figure 3 was oo rapid to give an equilibrium condition. For this reason he dust at 32 per cent humidity when curve C was measred would not have exactly the resistance that would be btained from Figure 2. Nevertheless the curves of igure 3 do show qualitatively the manner in which current hanges with humidity. High resistivities give severe everse-ionization and currents large as compared to that or a clean cell. Moderate resistivities, particularly at ower voltage, give a reduction in current. A thick dust ayer would give a greater reduction in current than the hin dust layer used in these tests.

In another series of tests the efficiency of a precipitator as measured when the large electrodes of the ionizer were coated with a thin layer of this fly ash. The precipitator was tested when cleaning normal city air and the efficiency measured using the filter-paper discoloration method.[8] A duct added for test purposes reduced the air flow slightly below rated velocity. Under these test conditions the efficiency measured at 54 per cent relative humidity was 95.5 per cent. This is approximately the efficiency of the precipitator with clean electrodes. At a humidity of 15 per cent the efficiency dropped to 71 per cent and at 7 per cent relative humidity the efficiency was 54 per cent. Three tests were made at 12 per cent relative humidity but regulating the ionizer voltage by means of a separate power supply so as to maintain the current at approximately the normal value for a clean cell. In tests 4, 5, and 6 the current was 500, 550, and 600 microamperes respectively, and resulted in efficiencies of 80 to 83 per cent. These tests indicate that if the resistivity is high, satisfactory performance is not secured by adjusting the voltage to give a normal ionizing current.[9]

The dust layer was then saturated with Celluflex, which is a tricresyl phosphate base adhesive with a wetting agent added so that the resistivity of the adhesive is relatively low. The unit then was tested at humidities duplicating

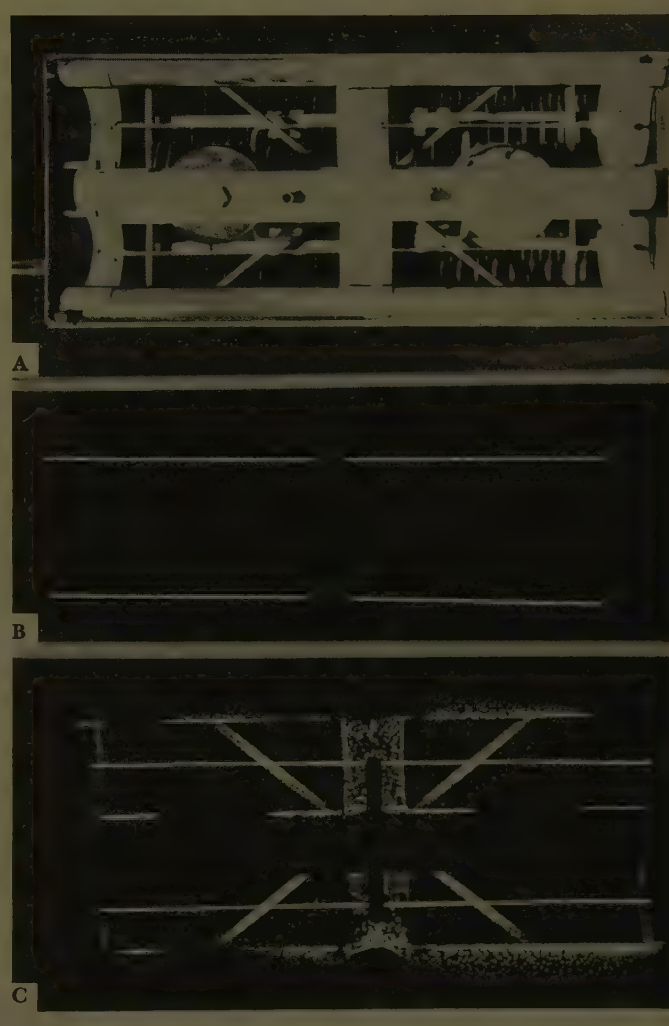


Figure 4. (A) Structure of the precipitator cell. (B) The same view taken in a dark room showing normal discharge at the wires. (C) Again the same view taken in a dark room showing reverse-ionization

tests 1, 2, and 3. With the dust saturated with low resistivity adhesive the efficiency remained at 95.5 to 96 per cent regardless of humidity.

Photographs were taken to show the appearance of the ionizer discharge under typical conditions. Figure 4*A*

Table I. Effect of Humidity on Efficiency

Electrodes Coated with Fly Ash

Test Number	Surface Condition of Large Electrode	Temperature (Degrees Fahrenheit)	Relative Humidity (Per Cent)	Current (Microamperes)	Efficiency (Per Cent)
1	Coated with Fly Ash dry	63	54	550	95.5
2		79	15	800	71
3		102	7	1150	54
4		118	12	500*	83
5		118	12	550*	82
6		118	12	600*	80
7	Coated with Fly Ash saturated with Celluflex	63	50	600	95.8
8		83	14	Not measured	95.6
9		109	6	600	96

* Ionizer voltage was varied to maintain specific current.

shows the appearance of the ionizer with the thin deposit of dust. Figure 4*B* was taken in a darkened room with the ionizer energized under conditions giving no reverse-ionization. This was a 15-minute exposure at f4.5 and shows the glow along the ionizer wire as it appears when viewed in a darkened room. Figure 4*C* is similar to 4*B* except taken under conditions giving reverse-ionization. The glow at the large electrodes as well as along the wires is clearly visible. Most of the center large electrode is behind the member which supports the ionizer so that only a little of the glow on this electrode is visible.

DISCUSSION OF TEST RESULTS

THE TESTS THAT have been described were intended to study the nature of reverse-ionization and to investigate means for eliminating it. The nature of the trouble seems clearly indicated; however, the resistivity at which the trouble starts is more difficult to determine. The resistivity tests were intended to approximate the condition

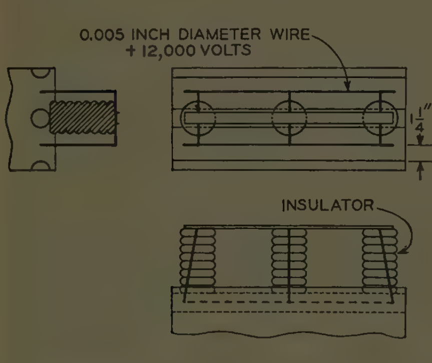


Figure 5. Electrode arrangement of the unit shown in Figure 4

of the dust on electrodes but there are several uncertainties. For example, the packing of the dust as deposited is probably different from the packing in the test cup. Electrically deposited dust tends to be spongy or porous so that the dust in the test cup may be more dense. The dust seems to exhibit a type of hysteresis so that the resistivity measured at a given humidity depends partly on previous history. A dust reaches equilibrium very slowly. The tests shown in Figure 2 are reasonably reproducible but the resistivity as given by the curve of Figure 2 would only approximate the resistivity at the same humidity under the conditions of the tests shown in Figure 3. Further tests also are needed to verify the correlation between resistivity and relative humidity. These uncertainties do not influence the qualitative analysis of the nature of reverse-ionization but do prevent an exact determination of the resistivity at which the trouble begins. Such a determination on this particular dust would be of rather limited value, however, because of the wide variation in types of dust that must be precipitated.

Further tests to study the point at which the efficiency is impaired seem very desirable. Tests 4, 5, and 6 of Table I exhibit a serious loss in efficiency even though the current was normal. These tests were made with a thin dust layer. A thicker deposit of dust would exhibit a larger decrease in current just below the resistivity at which reverse-ionization starts.

The increased generation of ozone which accompanies reverse-ionization is very noticeable to the sense of smell but was not measured in these tests. This increase is probably due to several factors. The increase in current would give, of course, a corresponding increase in ozone. Then the generation of ozone due to negative corona is normally higher than for positive corona. The most important factor is probably the change in the type of discharge when both positive and negative corona occur simultaneously.

Another difficulty that accompanies reverse-ionization is the increased tendency of the wire to vibrate. Wire vibration is troublesome because it shortens the life of the wire and because of the humming noise created. In case of severe vibration the amplitude may be sufficiently great to cause a spark-over between the wire and the large electrode. Even slight reverse-ionization increases the tendency of the wires to vibrate.

ELIMINATION OF REVERSE-IONIZATION

SINCE REVERSE-IONIZATION is caused by electrical breakdown of the layer of collected dust, it has been suggested that the trouble can be eliminated by frequent cleaning of the electrodes. This is not always successful because an extremely thin layer of high-resistivity dust can cause trouble. In these tests the electrodes were wiped off with a dry rag and yet a considerable increase in current occurred at low humidities, indicating reverse-ionization.

Reducing the ionizer voltage reduces the ionizer current and the resulting voltage gradient in the dust. While the voltage can be lowered until reverse-ionization ceases this is not generally practical. The resistivity of dust may be 20 times the resistivity required to cause reverse-ionization at normal voltage, so that the ionizing current would need to be reduced to 5 per cent of normal to eliminate reverse-ionization.

Since a small change in humidity results in a large change

n resistivity, the control of humidity is usually an effective and feasible means of eliminating reverse-ionization. Humidities considered desirable from a comfort standpoint usually result in a sufficiently low resistivity of the collected dust. Usually in precipitators cleaning normal ventilating air, little reverse-ionization is experienced when the humidity of the air which is entering the precipitator is controlled.

Adhesives have been found desirable as a means of retaining the precipitated dust. Most adhesives incorporate wetting agents to improve washability. This also results in a relatively low resistivity liquid. Saturating the dust with these adhesives is a very effective means for reducing the resistivity of the dust. A liberal amount of adhesive may be required because the surface layer of dust must be wetted.

CONCLUSION

HIGH RESISTIVITY dusts may result in excessive voltage gradients across the layer of collected dust on the large electrodes of the ionizer. This results in electrical breakdown through this dust layer and a negative corona at the surface of the large electrode. This supplies negative ions to neutralize partially the normal positive charge imparted to dust particles. Reverse-ionization reduces the efficiency of precipitation and causes excessive ozone generation and wire vibration. Reverse-ionization is probable if the resistivity of the dust is greater than 10^{11} ohm-centimeters and is improbable below 5×10^9 ohm-centimeters.

Control of humidity can keep the resistivity of the collected dust below objectionable limits and is usually an effective and feasible means of eliminating reverse-ionization. The use of liberal amounts of adhesive is also an effective means of eliminating trouble.

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Internally Cooled Generator Coils Increase Ratings by One-Half

C. M. LAFFOON
FELLOW AIEE

A new method of cooling large turbine generators makes it possible to increase ratings by one-half. The technique consists of blowing hydrogen gas at high velocity through specially constructed hollow generator coils.

A RADICALLY NEW method of cooling large turbine generators greatly increases the ratings in which these high-speed machines can be built. The practical benefits of this development also extend to smaller than maximum-size units because a machine of a given rating can be made smaller than with conventional cooling. The basis of the new ventilation technique is to cool the active conductors internally by making them hollow and blowing hydrogen gas at high velocities through these ducts, thus placing the coolant in intimate contact with the material in which the heat is generated.

This method of ventilation has been carefully tested on large size models. The results have warranted its application to two 3,600-rpm generators, rated at 175,000 and 200,000 kw, to be completed in 1954.

The new ventilation system comes at a fortunate time. The maximum practical rating of turbine generators has, over the years, risen steadily. By increasing hydrogen pressure, by improvements in blowers, in metallurgy, and in many construction details it has always been possible to keep pace with the demands for power-generation units. However the need for larger and larger machines is now growing rapidly. With existing labor and materials costs, and the need to keep electric power costs low, it becomes increasingly necessary for electric utility companies to install the largest generating units that can be utilized effectively by the individual systems and the systems with which they are interconnected. Several utility systems in the United States are of sufficient size and closely integrated by interconnection with other similar systems to justify generating units of 200,000-kw capacity and larger.

The cross-compound type of steam turbine generating units can be built for ratings up to 300,000-kw capacity at 3,600 rpm, or a combination of 1,800 and 3,600 rpm. Generators for this type of unit could deliver their kilowatt

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output ratings at power factors of 0.8 to 0.85 and short-circuit ratios of 0.8 to 0.9 when using hydrogen-gas pressures of 30 pounds per square inch gauge.

Since the tandem-compound turbine generator unit has fewer bearings, higher output efficiency, lower capital and operating costs, and requires less space in the generating plant, there is an economic need to develop it for larger ratings. Although tandem-connected generators also can be built for ratings up to 300,000 kw, this type of unit would probably represent little savings or advantages over the cross-compound unit and consequently would not be preferred normally. On the basis of available materials, present design practices, generator characteristics, and conventional construction, single-unit generators can be built at 3,600 rpm for maximum rating of 200,000 kw or slightly larger at 0.85 power factor, 0.8 short-circuit ratio, and 30 pounds per square inch gauge hydrogen pressure. The rotors of the units for these large ratings would operate above the first and probably above the second critical speed. At 0.9 power factor and 0.5 short-circuit ratio, the maximum generator rating could be increased to 230,000 kw.

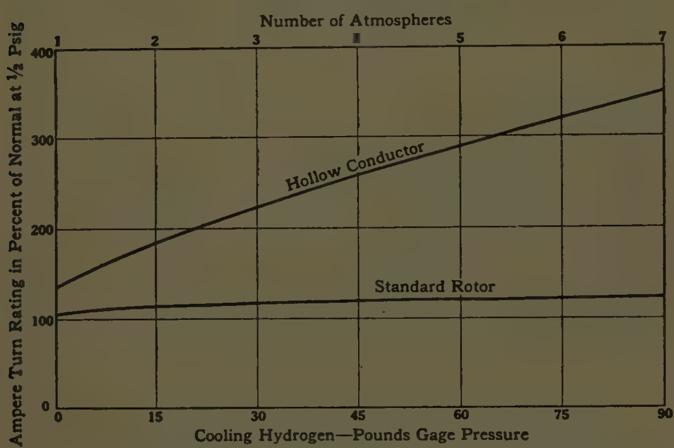

Figure 1. Effect of hydrogen pressure on ampere-turn rating for hollow conductor and standard rotor

Further incremental improvements in the physical, magnetic, electrical, and thermal properties of steel, copper, and insulation, in conjunction with improved ventilation, will make possible a further increase in output per unit of generator weight and ultimately result in still larger generator ratings. However, to secure a major increase some radically new feature is needed. During recent years, much attention has been given to possibilities of using other cooling media as a means of overcoming this limitation but as yet none of these schemes has proved practical. The answer to a substantial improvement is believed to lie in internal cooling of rotor and stator windings with high-density hydrogen. This offers possibilities of greatly increasing the amount of copper losses that can be dissipated for a given maximum temperature rise. With the heat flow through the insulation of the windings almost completely eliminated, the temperature of the windings is determined by the temperature of the hydrogen gas in contact with the copper and the heat transfer coefficient from the copper to the gas.

The curves in Figure 1 show the rotor ampere conductors per slot obtainable from tests on a full-size stationary model, with the average and maximum copper temperature maintained the same for the two types of construction. The lower curve is for the conventional rotor design with external cooling, and shows that further increase in hydrogen pressure will offer very little increase of rotor ampere conductors. On the other hand, the benefit with hollow conductors is tremendously higher. The increase is extremely high for the higher gas pressures.

The phenomenal increase in ampere conductor output for the inner-cooled rotor winding is obtained by passing large masses of hydrogen gas through internal passages of the conductors at relatively high velocities. It is therefore obvious that the full advantage of inner cooling is basically associated with high hydrogen pressures and requires use of high-pressure blowers to circulate the gas through the internal ducts.

A section view of a rotor and rotor winding, Figure 2, shows the path of the hydrogen gas flowing through the rotor conductors for a particular type of construction. The rotor-winding insulation problems are fundamentally the same as for present conventional construction. Creepage paths of the conductors at the central discharge sections are of the same magnitude as for the end turns of present machines. Although the tapered rotor slot may prove to be more difficult to machine, its use results in a much simpler blocking for the straight portion of the rotor coil ends. The end turn blocking is further simplified by elimination of gas flow between coil sides and the use of a constant cross section of copper for the circumferential portion of the rotor end turns. In this type of rotor the

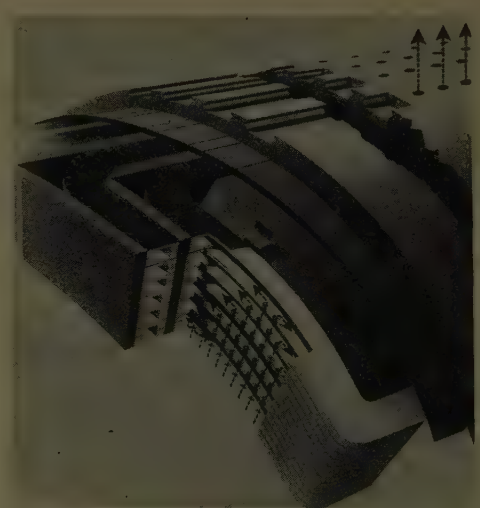

Figure 2. Section view of rotor and rotor winding

conductors are necessarily of large cross section and few in number. With the rotor ampere conductors vastly increased by internal cooling, the field current is large, the field voltage relatively low, and the excitation input approximately twice that for a rotor of a generator of conventional design. Rotating coil models of large size have been built and tested to demonstrate that internal blowers

mounted on ends of the rotor can deliver the required mass of hydrogen through the rotor conductors.

This article has applied only to rotor cooling. Similar benefit can result from internally cooling the stator coils. The insulation problem is more difficult for stator coils because of the higher voltage involved and the need for creepage paths of greater length over that required for the rotor. With machines in which the cooling can be accomplished by passing the hydrogen gas through the full length of the coils, the creepage problems are relatively simple and no difficult mechanical and ventilation problems are involved. In the longer machines, in which a central hydrogen discharge is required, the creepage problems are more difficult but do not appear to be unsolvable. At present, the development of the inner-cooled stator coil has not been carried to the same stage as for the rotor, and it therefore may be advisable to apply internal cooling in two steps—the first step for the rotor alone, and the second for the stator.

The curves of Figure 3 show what can be expected of internally cooled rotor windings and both rotor and stator windings as compared with conventional designs. The kilowatt ratings are based on 0.85 power factor, 0.8 short-circuit ratio, and operation at 30 pounds per square inch gauge hydrogen pressure. From a magnetic standpoint, no changes have been made in flux densities in the stator and rotor portions of the magnetic circuit. In comparing the physical dimensions of a 200,000-kw unit for the two types of design, the size factor for the rotor with inner cooling of the conductors is only 62 per cent of that for the conventional rotor. The reduction in stator dimensions is of smaller magnitude since internal cooling of the stator conductors is not used.

In the case of internal cooling for both stator and rotor windings, the rotor size factor is only 50 per cent of that for the conventional machine of the same rating and performance characteristics; a similar reduction in the size factor for the stator also would be obtained.

The development of internal cooling with high-pressure hydrogen gas opens up a new era in the design and construction of turbine generators without too great a departure from present practice and experience. The increased output per unit of generator weight makes possible smaller units for a given rating and appreciably larger maximum ratings at 3,600 rpm than heretofore obtainable with conventional designs. The over-all efficiency performance including generator bearing losses then will be essentially the same as for units of present conventional designs. The increase in copper losses of the stator and rotor windings due to higher current densities is more than offset by the reduction in bearing losses resulting from the smaller bearings required for the smaller rotors, and the reduction in rotor surface losses resulting from the appreciable increase in the radial length of the air gap and the decrease in rotor surface area. The increase in ventilation loss due to higher fan pressures is partially offset by the reduction in the volume of gas to be delivered by the blowers. For turbine generators with internal cooling of the conductors, the excitation and terminal voltages are lower than for similar ratings of conventional design because of the mechanical requirement for larger over-all section for the rotor conductors and the inherent limitations in insulation surface creepage at the inlet and discharge sections of the conductors for both windings.

Internal cooling of the rotor and stator windings of turbine generators with high density hydrogen is par-

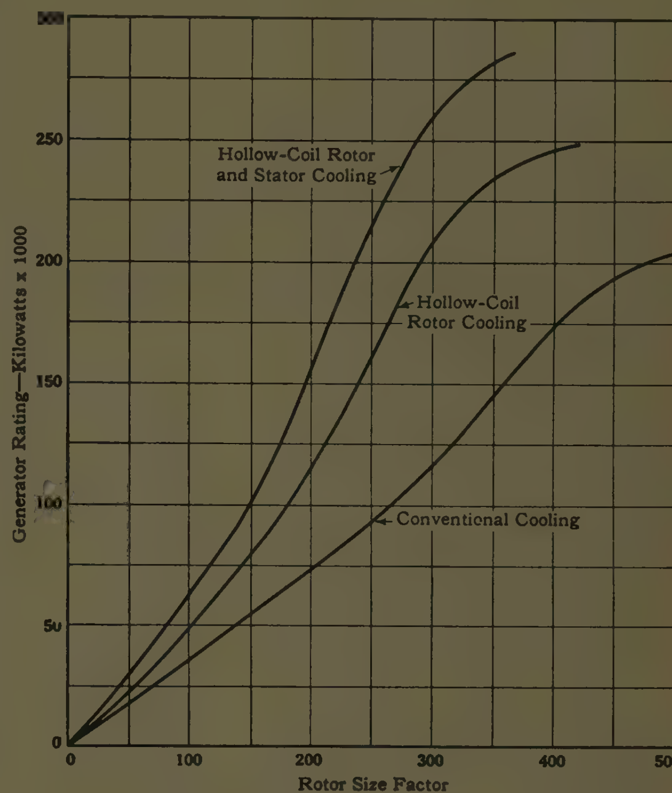

Figure 3. How internal cooling will affect generator rating

ticularly applicable to units for ratings of 90,000 kw and above. The improved cooling makes possible the construction of ratings much larger than now possible with conventional gas cooling. Ratings of 3,600-rpm single-unit generators of 250,000 to 275,000 kw now appear possible at power factors and stability characteristics suitable for the large electric utility systems. Under present conditions, the reduction in physical size of generating units for a given rating is of paramount importance since it results in the conservation of our nation's two most necessary critical materials—copper and steel. Although the cost savings resulting from the use of less materials are more than offset at the present state of the development by the large development cost required, large capacity turbine generator units of this type, even at present unit costs, should result in lower over-all station capital and operating costs without any sacrifice in efficiency performance. The reduced physical size of the rotor element simplifies the forging problem and results in improved mechanical performance and reliability. In addition to the two large machines now being constructed with internally cooled rotors, a 90,000-kw 3,600-rpm generator, using internal cooling for both stator and rotor windings, is now being designed and is expected to be built and available for testing during the latter part of 1952.

INSTITUTE ACTIVITIES

1952 Winter General Meeting to Offer 68 Technical Sessions and Conferences

Sixty-eight technical sessions and conferences are already planned for the 1952 Winter General Meeting to be held January 21–25 at the Hotel Statler, New York City, N. Y. As the 1951 meeting exceeded in size and attendance the meeting which was held in 1950 so this year's meeting is expected to exceed the previous figures by a substantial margin. It is fully expected that the maximum number of technical sessions which can be scheduled will be reached before the final program is announced.

TECHNICAL SESSIONS

As this issue goes to press the following technical committees of the Institute have requested time and space for technical sessions and conferences: Communication Switching Systems, Radio Communication Systems, Special Communication Applications, Television and Aural Broadcasting Systems, and Wire Communication Systems in the Communications Division.

In the Power Division, the committees on Carrier Current, Insulated Conductors, Power Generation, Protective Devices, Relays, Rotating Machinery, Substations, Switchgear, System Engineering, Transformers, and Transmission and Distribution are planning a total of 22 technical sessions and conferences.

In the Science and Electronics Division 25 sessions have been requested by the Committees on Basic Sciences, Computing Devices, Electronic Power Converters, Electronics, Instruments and Measurements, Magnetic Amplifiers, Metallic Rectifiers, and Nucleonics.

Seven technical sessions are being organized by the committees on Air Transportation, Land Transportation, Domestic and Commercial Applications, and Production and Application of Light in the General Applications Division.

In addition, in the Professional Division, the committees on Education and Safety are each planning one technical session.

THEATER TICKETS

It is expected that tickets for the following shows will be available to out-of-town AIEE members during the week of the meeting. Prices are for orchestra seats Monday, January 21, through Thursday, January 24, evenings:

A Tree Grows In Brooklyn	$7.20
Affairs of State	4.80
Call Me Madam	7.20
Guys and Dolls	6.60
Seventeen	6.00
South Pacific	6.00
The King and I	8.40*
Two on the Aisle	6.00

*These tickets are not available to us from the box office and must be obtained through brokers. The price shown includes broker's fee. It may become necessary to classify additional shows in this category.

Requests should include checks payable to "American Institute of Electrical Engineers," first and second choice of both name and date of show, and should be sent to Theater Ticket Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. Preference will be given to requests for seats in blocks of pairs and the committee reserves the right to reduce requests to sell-out shows to two tickets and will refund all money received for unsatisfied requests.

HOTEL RESERVATIONS

Blocks of rooms have been set aside at the Hotel Statler (meeting headquarters) and nearby hotels for members and guests attending. Requests for reservations should be sent as early as possible, directly to the hotel of choice, and to only one hotel. Mention AIEE in your request and send a copy to Mr. W. G. Vieth, Vice-Chairman, Hotel Accommodations Committee, c/o Western Union Telegraph Company, 60 Hudson Street, New York 13, N. Y. A second and third choice should be noted on this copy. If the accommodations are not available at the hotel requested, the Hotel Accommodations Committee will transfer the request to one of the other hotels.

Hotel Rooms have been reserved at the following hotels, and all rates are subject to a 5 per cent New York City hotel room tax.

Hotel Statler (meeting headquarters)
7th Avenue, 32nd to 33rd Streets

Single room with bath	$ 5.00 to $ 8.50
Double room, double bed	8.00 to 10.50
Double room, twin beds	9.00 to 15.00
Parlor Suites	22.00 to 24.00

Hotel Governor Clinton, 7th Avenue at 31st Street

Single room with bath	$ 5.00 to $ 7.00
Double room, double bed	8.00 to 9.50
Double room, twin beds	9.00 to 11.00

Hotel McAlpin, Broadway and 34th Street

Single room with bath	$ 5.00 to $ 9.00
Double room, double bed	8.00 to 12.00
Double room, twin beds	9.00 to 13.00

Hotel New Yorker, 34th Street and 8th Avenue

Single room, tub and shower	$ 5.00 to $ 8.00
Double room, double bed	8.00 to 13.00
Double room, twin beds	9.50 to 14.00

Hotel Martinique, Broadway and 32nd Street

Single room with bath	$ 4.00 to $ 6.00
Double room, double bed	6.50 to 10.00
Double room, twin beds	7.50 to 10.00

Hotel Commodore, 42nd Street at Lexington Avenue

Single room with bath	$ 5.50 to $10.00
Double room, double bed	9.00 to 11.00
Double room, twin beds	10.00 to 13.00

Hotel Roosevelt, Madison Avenue at 45th Street

Single room with bath	$ 6.50 to $10.00
Double room, double bed	12.50 to 16.00
Double room, twin beds	13.50 to 17.00

DINNER-DANCE

The dinner-dance promises to be the usual outstanding social event for the convention delegates and their ladies. It will be held Thursday, January 24, in the main ballroom of the Hotel Statler. Formal dress is requested. Reservations may be made with the Dinner-Dance Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. Each table will seat a group of 10 persons. The committee is under the chairmanship of J. G. Derse.

SMOKER

The Smoker Committee, under the chairmanship of D. M. Quick, announces that the Smoker will be held at the Hotel Commodore on Tuesday evening, January 22. Reservations should be sent to the Smoker Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y., at an early date.

LADIES' ENTERTAINMENT

The Ladies' Entertainment Committee, under the chairmanship of Mrs. R. F.

Future AIEE Meetings

AIEE Machine Tool Conference (*page 1018*)
Hotel Faust, Rockford, Ill.
November 14–16, 1951

AIEE Conference on Feedback Control Systems (*page 1019*)
Haddon Hall Hotel, Atlantic City, N. J.
December 6–7, 1951

Joint AIEE-IRE Computer Conference (*page 1019*)
Benjamin Franklin Hotel, Philadelphia, Pa.
December 10–12, 1951

AIEE Conference on Electronic Instrumentation in Nucleonics and Medicine (*page 1020*)
Hotel Commodore, New York, N. Y.
January 7–8, 1952

Winter General Meeting (*page 1016*)
Hotel Statler, New York, N. Y.
January 21–25, 1952
(*Final date for submitting papers—closed*)

South West District Meeting
Jefferson Hotel, St. Louis, Mo.
April 15–17, 1952
(*Final date for submitting papers—January 16*)

North Eastern District Meeting
Binghamton, N. Y.
April 30–May 2, 1952
(*Final date for submitting papers—January 31*)

AIEE Conference on Electronic Converter Applications and Tubes
William Penn Hotel, Pittsburgh, Pa.
May 5–6, 1952

Summer General Meeting
Hotel Nicollet, Minneapolis, Minn.
June 23–27, 1952
(*Final date for submitting papers—March 25*)

Pacific General Meeting
Phoenix, Ariz.
August 19–22, 1952
(*Final date for submitting papers—May 21*)

Brower, is planning a program of unusual interest for the ladies. On Monday, January 21, there will be the usual "Get Acquainted" Tea at the Ladies' Headquarters in the Statler.

WINTER GENERAL MEETING COMMITTEE

The members of the 1952 Winter General Meeting Committee are: G. J. Lowell, *Chairman;* C. T. Hatcher, *Vice-Chairman;* J. J. Anderson, *Secretary;* W. J. Barrett, *Budget Co-ordinator;* C. S. Purnell, *Vice-President, District 3, AIEE;* M. M. Brandon, *Technical Program;* J. P. Neubauer, D. W. Taylor, J. D. Tebo, D. T. Braymer, *General Session;* R. T. Weil, *Monitors;* G. T. Minasian, J. B. Harris, Jr., *Publicity;* C. N. Metcalf, *Hotel Accommodations;* E. R. Thomas, *Registration;* D. M. Quick, *Smoker;* Mrs. R. F. Brower, *Ladies' Entertainment;* J. G. Derse, *Dinner-Dance;* F. P. Josslon, *Inspection Trips;* J. G. Aldworth, *Theater-Radio.*

EJC Approves Recommendations of Special Panel on Salary Stabilization

The constituent member societies of Engineers Joint Council (EJC) appointed a Special Panel of Engineers Advisory to the United States Salary Stabilization Board to study engineering problems in salary stabilization. Recommendations of the Special Panel were approved by EJC at their September 14 meeting. The statement follows:

ENGINEER PROBLEMS IN SALARY STABILIZATION

(*A Statement with Recommendations*)

1. The increase in the industrial and technical load to prepare the nation's economy for defense has resulted in an unusual and sudden demand for engineers which has created many inequities and imbalances in engineering salaries.

2. Engineers are in short supply. The situation will get worse and there is no immediate solution in sight. Immediate alleviation can come only by more rapid advancement of those who show capacity for broadening their activities and assuming additional responsibilities. Adequate salary treatment in such cases is imperative.

3. The normal process of development of the engineer from graduation includes a period of training in industry and progressive growth to increased responsibility in all phases of engineering practice.

4. One of the inherent difficulties in comparing the values of engineering services is the difficulty in describing or classifying the skills that are used. As the engineer advances in experience, he is able to grasp engineering problems and evolve engineering designs more quickly, the volume of the work he produces increases, and yet he may continue to hold the same job designation he had when he started his work.

5. Not only does an engineer become more productive as he gains experience, but actually the contributions of each individual vary widely depending on his creative ability, training, and other personal characteristics. Therefore, in the absence of a plan which provides for promotion of an engineer from one arbitrary job classification to another, each merit increase may be, at least partly, a promotion increase and must be made on the basis of an appraisal of the individual's growth and contribution to the business.

6. More recent graduates are needed than are available. This shortage has led to the payment of increased starting salaries by many employers at rates that are materially above the rates the same employer was paying before 1950. Experienced engineers also are in short supply and many are underpaid.

7. The justifiable increases in starting rates for engineers that have been made effective since 1949 have in many cases flattened the previous experience-salary curves. This is because employers have not always made increases in the compensation of experienced engineers in proportion to increased starting rates. This has resulted in serious inequities as between salaries of older engineers and salaries of those just starting their careers.

8. Differentials which normally exist between engineering and executive salaries and those of nonexempt employees with whom they are associated (draftsmen, clerks, mechanics, and so forth) are either materially reduced or disappear altogether when, in a period like the present, industry finds it necessary to operate on schedules in excess of 40 hours per week. This is particularly true of the younger or lower-paid professional employees and executive employees. Overtime payment practices for exempt employees vary widely between companies. The Salary Stabilization regulations should be amended to permit the payment of premiums for scheduled overtime to exempt employees not to exceed the treatment given nonexempt employees in the same organization.

9. Certain segments of the engineering profession were at abnormally low salary levels at the time of the salary freeze. A serious loss of technical personnel in these elements of the economy is being created because of their depressed salary rates. Methods must be provided to permit the equalizing of salary rates to obtain a balanced distribution of professional personnel in all phases of engineering service in the national economy.

10. To minimize the tendency of engineers to shift from one organization to another due to the factors enumerated here, with resulting loss of productivity, it is believed that prequalification should be required of contractors, whether for engineering services, construction, or supply. In addition, as recommended specifically in item 11, opportunity should be afforded to employers to compensate their engineers fairly and adequately, thereby permitting those organizations that are essential to national health, welfare, and defense of the country to maintain their professional staffs.

11. All these considerations lead to the following RECOMMENDATIONS of Engineers Joint Council, representing a membership of 130,000 engineers, that the regulations of the Salary Stabilization Board should permit:

(a) Correction of salary inequities created by the current high level of starting salaries of young engineers so as to permit commensurate increases of salaries for older, qualified, and well-experienced engineers.

(b) Correction of salary inequities in areas where engineering salaries were abnormally low at the time of the wage and salary freeze.

(c) Clarification of Section 8(6)e of the Circular *GSSR Number 1* to indicate flexibility of treatment of so-called "rare and unusual cases" as concerning engineers because of the existing serious manpower shortage of engineers.

(d) Appropriate salary increases for professional employees and others in cases where responsibilities vary with the competencies of individuals, and where the job classifications are impracticable.

(e) Premiums for scheduled overtime to exempt employees not to exceed the treatment given nonexempt employees in the same organization.

Regular Meeting of AIEE Board of Directors Held in Portland, Oregon

A regular meeting of the Board of Directors of the Institute was held in the Pacific Telephone and Telegraph Building, Portland, Oregon, August 23, 1951.

The minutes of the meeting of the Board of Directors held in Toronto on June 28, 1951, were approved.

A resolution in memory of Past President Dugald C. Jackson, who died July 1, 1951, was adopted, as follows:

Whereas: With the death of Dr. Dugald Caleb Jackson (A '87, M '90, F '12, Honorary Member '44, Member for Life) there has passed from our midst one of the outstanding leaders in the professional field of engineering.

And: As President of the American Institute of Electrical Engineers (1910–11), Edison Medalist (1938), and one active in the committee work of the Institute for many years, and in the promotion of professional ethics among engineers, Dr. Jackson has set a noteworthy example before the electrical engineers of today and the future.

And Further: As a great teacher and university administrator Dr. Jackson had much to do with the formulation of the pattern of modern electrical engineering education and of the relation between educational institutions and industry.

Now Therefore Be It Resolved: That the Board of Directors of the American Institute of Electrical Engineers in meeting duly assembled and acting in behalf of the members of the Institute hereby expresses its keenest regret at the death of Dr. Jackson and directs that deepest sympathy and sincere condolences be extended to the members of his family.

Director E. W. Davis was appointed AIEE representative to attend a memorial

service for Dr. Jackson held October 21.

Recommendations of the Board of Examiners adopted at a meeting on July 19, 1951, regarding membership applications, were reported and approved. The following actions were taken upon recommendation of the Board of Examiners: 36 applicants were transferred to the grade of Fellow; 199 applicants were transferred, 32 were elected, and 2 were re-elected to the grade of Member; 453 applicants were elected, 1 was reinstated, and 12 were re-elected to the grade of Associate Member; 44 Student members were enrolled.

At the meeting of the Board of Directors held June 28, the Membership Committee was requested to make recommendations regarding a badge for Affiliates. The committee reported its recommendation of an Affiliate badge using the present design with a green background, and the Board adopted the recommendation.

FINANCES

Chairman Barrett of the Finance Committee reported disbursements from general funds as follows: July, $70,236.90; August, $58,134.33.

He reported loans for four forthcoming special technical conferences, and stated that nearly all such conferences have been self-supporting.

Mr. Barrett reported that the income to July 31, 1951, was 87.4 per cent of the estimated income for the appropriation year ending September 30, 1951. For the corresponding period last year, the income was 86.4 per cent of the total for the year. Disbursements to July 31, 1951, had been 81.6 per cent of the estimated disbursements during the appropriation year. For the same period last year, the disbursements were 85.8 per cent of the total expended during the year ended September 30, 1950.

Chairman Barrett reported that the expenditure this year for travel expenses to District conferences on Student activities was likely to exceed the appropriation by $3,300 to $3,500, the excess over the estimate being due largely to the fact that the District 4 conference was held at Miami Beach, an extreme corner of the District. The location was not known when the budget was prepared. The Board voted to increase the appropriation for District Student conferences by $3,500.

AMENDMENTS TO BYLAWS

Substantially in accord with recommendations of the Committee on Constitution and Bylaws, the Board adopted amendments to Sections 6, 7, and 31 of the Bylaws as follows:

Section 6: In the second line of the first paragraph, the words "or Fellows" were deleted. The third paragraph was deleted.

Section 7: In the first line, the word "grades" was changed to "grade," and in the second line, the words "and Fellow" were deleted. In the fifth line, the word "signed" was substituted for the word "written."

Section 31: Amended to read as follows, upon recommendation of the Sections Committee and upon recommendation adopted at a conference of Vice-Presidents and District Secretaries in June: "To facilitate co-operation among the Sections there shall be an executive committee in each geographical District, including in its membership the Vice-President representing the District on the Board of Directors as chairman, a District Secretary to be appointed by the Vice-President as secretary, the vice-chairman of the Membership Committee, who may be a member of the District executive committee in another capacity also, and the chairman and one other officer selected by the executive committee of each Section within the District; also, a member of the Sections Committee who is resident in the District, and in order to encourage co-operation between Sections and Branches, the chairman of the District committee on Student activities. In case of inability of either representative of a Section mentioned above to attend a District executive committee meeting, the Section may, with the approval of the Vice-President, designate an alternate who shall have full voting power.

"At the first executive committee meeting of any District, when a new Vice-President is presiding for the first time, the outgoing Vice-President of that District shall be an active voting member of the District executive committee for this one meeting."

SECTIONS COMMITTEE

Upon recommendation of the Sections Committee, the Board authorized a change in name of the New Mexico-West Texas Section to El Paso Section.

COMMITTEE ON PLANNING AND CO-ORDINATION

There was a discussion of the subject of divisional operation of technical activities of AIEE, which is to be discussed at the forum of technical committee chairmen in October.

APPOINTMENT OF COMMITTEES AND REPRESENTATIVES

The following actions were taken by the Board in compliance with requirements in the bylaws of the committees concerned:

Charles LeGeyt Fortescue Fellowship Committee. Confirmed the appointment by the President of F. H. Pumphrey and J. D. Ryder as members of the committee for the term of three years which began August 1, 1951.

Edison Medal Committee. Confirmed the appointment by the President of A. H. Frampton, J. R. North, and B. Richard Teare for the term of five years which began August 1, 1951, and the appointment of J. F. Calvert as chairman of the committee for the year 1951–52.

Elected the following Board members to serve on the committee for the term of two years which began August 1, 1951: F. R. Benedict, J. D. Harper, and Victor Siegfried.

Lamme Medal Committee. Confirmed the appointment by the President of A. M. MacCutcheon, B. L. Robertson, and Elgin B. Robertson for the term of three years which began August 1, 1951.

Representatives of the Institute on various organizations were appointed, and are listed on page 938 of the October issue of *Electrical Engineering.*

APPOINTMENT OF LOCAL HONORARY SECRETARIES

The following Local Honorary Secretaries of AIEE were reappointed for the term of two years which began August 1, 1951: Sir A. P. M. Fleming for England, R. D. Neale for New Zealand, and Edy Velander for Sweden.

ECPD APPOINTMENTS

Dr. D. D. Ewing was appointed a representative of AIEE on Engineers' Council for Professional Development (ECPD) for the 3-year term beginning in October 1951, succeeding Prof. M. S. Coover, whose term will expire at that time.

The Board approved appointment of the following Institute members to ECPD committees for the year beginning in October, as recommended by the Executive Committee of ECPD: *Guidance,* M. S. Coover, J. H. Lampe; *Education,* Harold L. Hazen; *Training,* Donald Bridgman, Karl B. McEachron, Jr.; and *Recognition,* R. H. Barclay.

GENERAL

It was voted that greetings to the American Chemical Society in the form of a scroll be presented by Vice-President C. S. Purnell, as the representative of the Institute, on the occasion of the celebration of the 75th anniversary of that society, in New York City, September 3–7, 1951.

A representative to attend the inauguration of J. H. Davis as President of Stevens Institute of Technology, on October 12, 1951, was appointed by Vice-President Purnell.

Vice-President J. C. Strasbourger is to represent the Institute at the 60th anniversary celebration of the Drexel Institute of Technology, October 30–November 1, 1951.

Present at the meeting were: *President* F. O. McMillan; *Past President* T. G. LeClair; *Vice-Presidents* J. D. Harper, N. M. Lovell, J. A. McDonald, F. W. Norris, J. R. North, C. S. Purnell, J. C. Strasbourger; *Directors* W. J. Barrett, F. R. Benedict, R. F. Danner, D. D. Ewing, N. B. Hinson, M. D. Hooven, H. J. Scholz, Victor Siegfried; and *Secretary* H. H. Henline.

AIEE Machine Tool Conference to Be Held in Rockford, Ill.

The Fourth Annual AIEE Machine Tool Conference will be held November 14, 15, and 16, 1951, at the Hotel Faust in Rockford, Ill. The Machine Tool Subcommittee of the AIEE Committee on General Industry Applications, and the Rock River Valley Section of AIEE, will be hosts. More than 250 engineers attended last year's conference in Worcester, Mass. It will be possible to accommodate more this year.

Burnham Finney, editor of *American Machinist,* will be the guest speaker for the dinner meeting. His topic, "Machine Tools—The Next Ten Years," will be a challenging discussion of the trend in machine tool use in the future.

Those who wish to attend this conference should write to Mr. B. T. Anderson, Chairman, AIEE Conference on Machine Tools, c/o Sunstrand Machine Tool Company, Rockford, Ill.

The first two days the technical session will be held, and both the morning and afternoon of the third day will be devoted

plant visitations in Rockford and the surounding area.

An interesting technical program has been lanned, as follows:

Vednesday, November 14, 1:00 p.m.

Value of the J. I. C. Standards in the Automotive ndustry. *R. W. Kowitz*, Ford Motor Company

Design of Control Circuits for Machine Tools. *J. M. Rodgers*, Delco Products

nformation Required for Trouble Shooting on Mahine Tools. *J. P. Bellafaire*, Chevrolet Gear and xle Division

Thursday, November 15, 9:00 a.m.

Electrical Resistance Strain Gage Studies of Dynamic Loads in Machine Tools. *Donald K. Schaeve, Joseph A. weeney*, Barber-Colman Company

witches for Electrical Control of Machine Tools. *. L. Riche*, Micro Switch Company

election of Flywheel and Motor Slip for Pulsating Loads. *L. W. Herchenroeder*, Westinghouse Electric Corporation

Analysis of an Adjustable Speed Drive Using the Adjustable Voltage Direct Current Principle Incorporating Magnetic Amplifier Control. *W. J. Altschwager*, Louis Allis Company

Thursday, November 15, 1:30 p.m.

Basic Method of Rating Motors for Continuous and Intermittent Duty Applications. *Earl Barnes*, Reliance Electric and Engineering Company

Mineral Insulated—Metal Sheathed Wiring. General Cable Company

Load Indicators and Load Control Systems for Machine Tools. *B. F. Bennett*, General Electric Company

New Developments in Clutches and Brakes. *Paul A. Harter*, Warner Electric Brake and Clutch Company

Program for Feedback Control Systems Conference Released

A 2-day Conference on Feedback Control Systems will be held on December 6 and 7, 1951, at the Chalfonte-Haddon Hall Hotel in Atlantic City, N. J. The conference is being sponsored by the AIEE Committee on Feedback Control Systems, and the chairman of this committee, Dr. S. W. Herwald of Westinghouse Electric Corporation in East Pittsburgh, Pa., will give the opening address.

The tentative technical program, consisting of four sessions, has been released, and is presented here.

Session I—Recapitulation of Technical Development

Presiding Officer, Dr. S. W. Herwald, Westinghouse Electric Corporation, East Pittsburgh, Pa.

Review of Developments in Systems Engineering in the U.S.A. and Abroad. *Dr. G. S. Brown*, Massachusetts Institute of Technology, Cambridge, Mass.

Review of the Role of Statistics in the Engineering of Feedback Control Systems. *Dr. J. R. Ragazzini*, Columbia University, New York, N. Y.

Application of Theory to the Practical Design of Airplane Controls. *Dr. O. H. Schuck*, Minneapolis-Honeywell Regulator Company, Minneapolis, Minn.

Session II—Component Developments

Presiding Officer, Dr. C. W. Miller, Perkin-Elmer Corporation, Norwalk, Conn.

Characteristics of Precision Computing Servo Potentiometers. *D. C. Duncan*, Helipot Corporation, Pasadena, Calif.

Servo Motors and Synchros. *D. W. Bloser*, Kearfott Company, Little Falls, N. J.

Electromagnetic Resolvers. *J. P. Toner*, Arma Corporation, Brooklyn, N. Y.

Practical Problems in Obtaining Good System Performance. *R. F. Redemske*, Servomechanisms, Inc., Westbury, N. Y.

Session III—Advanced Developments in Design Techniques

Presiding Officer, H. T. Marcy, I.B.M. Corporation, Endicott, N. Y.

On the Relation between Control Power and Systems Dynamic Response. *Dr. D. P. Campbell*, Massachusetts Institute of Technology, Cambridge, Mass.

Development in the Application of Discontinuous Control Systems. *Dr. R. J. Kochenburger*, University of Connecticut, Storrs, Conn.

Control Systems Operating from Discrete Data Inputs. *W. M. Pease*, Massachusetts Institute of Technology, Cambridge, Mass.

Sampled-Data Control Systems. *Dr. W. K. Linvill*, Massachusetts Institute of Technology, Cambridge, Mass.

Session IV—Feedback Control Systems and the Human

Presiding Officer, Dr. O. H. Schuck, Minneapolis-Honeywell Regulator Company, Minneapolis, Minn.

A Linear Approach to Biological Servos. *Dr. G. Kreezer*, George Washington University, Washington, D. C.

A Non-Linear Approach to Biological Servos. *Prof. O. H. Schmitt*, University of Minnesota, Minneapolis, Minn.

Incorporating the Human Operator in Feedback Control Systems. *Dr. L. S. Beals*, Commander, United States Navy, Special Devices Center, Office of Naval Research, Washington, D. C.

Program of Joint AIEE-IRE Computer Conference Released

A Joint AIEE-IRE Computer Conference will be held December 10–12 in Philadelphia, Pa., specifically to review accomplishments in the field of large-scale digital computer engineering. Papers from some 12 computing groups or manufacturing organizations which have succeeded in obtaining useful results from present large-scale digital computers will be presented.

A keynote address by Dr. W. H. MacWilliams, Jr., of the Bell Telephone Laboratories will precede the formal presentation of papers; Dr. J. W. Forrester will summarize the conference on Wednesday afternoon.

Inspection trips have been arranged for visiting the Bureau of Census UNIVAC at Remington-Rand, Eckert-Mauchly Division; Burroughs Research Division; Moore School of Electrical Engineering, University of Pennsylvania; and Technitrol Engineering Company. Reservations for these trips will be made at the conference due to the space limitations of these groups.

The Monday and Wednesday sessions will be held at the Benjamin Franklin Hotel and the Tuesday session in the Edison Building. The following program lists the machines which will be discussed:

Session	Machine	Manufacturer or User
Dec. 10	1101	Engineering Research Associates
	TESTRAC	Burroughs Adding Machine Corporation
	UNIVAC	Remington Rand, Eckert-Mauchly Division
Dec. 11	Card-Programmed Electronic Calculator	IBM Corporation
	Institute for Advanced Study Machine	Institute for Advanced Study, Princeton, N. J.
	ORDVAC	University of Illinois
	SWAC	Institute for Numerical Analysis, Los Angeles, Calif.
	Harvard MARK III	Dahlgren Proving Grounds
	University of Manchester Electronic Computer	Ferranti Ltd., England
Dec. 12	Whirlwind I	Massachusetts Institute of Technology
	EDSAC	Cambridge University, England
	SEAC	Bureau of Standards, Washington, D. C.

Richland Section Announces Winners of Contest Awards

The AIEE Richland Section Technical Papers Contest sponsored during the winter season of 1950–51 resulted in 13 papers. This is the second competition of this Section of 126 members. All of the competition papers were prepared by General Electric Company electrical engineers.

First prize was awarded to the paper entitled "Kilowatts and Atomic Energy," by H. A. Carlberg; second prize to T. B. Correy for "Salt Bath Resistance Furnace Problems;" and third prize for "The 480-Volt Delta System" by C. B. Wagner.

In addition, G. L. Swezea and B. J. Willingham received honorable mention for their papers, "Design Considerations for Electricity Metering in the Village of

The three prize winners of the AIEE Richland Section Technical Papers Contest are, left to right, C. B. Wagner, H. A. Carlberg, and T. B. Correy, all of the General Electric Company

Richland" and "Communication Requirements for Civil Defense" respectively.

Mr. Carlberg and Mr. Wagner presented their papers at the AIEE Pacific General Meeting this year, as did W. J. Dowis, who wrote "Atomic Energy and the Role of the Electrical Engineer." A paper entitled "Cathodic Protection of Stainless Steel Buried in the Ground," by F. J. Mollerus and J. F. Kane, also was presented at this meeting, as well as at the AIEE Fall General Meeting of 1950.

The three prize-winning papers and the two honorable mention papers, as well as the paper by Mr. Dowis, have been entered in the AIEE 9th District and National AIEE papers competitions and will be judged at a later date.

Electronic Instrumentation Conference to Be Held Jan. 7–8

The Fourth Annual Conference on Electronic Instrumentation in Nucleonics and Medicine will be held on January 7–8, 1952, at the Hotel Commodore, New York City, N. Y. The object of the conference is to draw medical and electronic personnel together so that they can familiarize themselves with each other's problems.

A lecture-demonstration showing the televising of microscopic images will be given on Monday evening, January 7, by Dr. V. K. Zworykin and Mr. Leslie Flory of the David Sarnoff Research Center, Radio Corporation of America.

The 2-day conference is divided into the following sessions:

Monday, January 7

9:30 a.m.—Nucleonics

2:00 p.m.—X rays and Gamma rays

Evening—Television lecture-demonstration

Tuesday, January 8

9:30 a.m.—Application of Circuit Theory to Medicine

2:00 p.m.—Applications of Electronics Technique in Anesthesia

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

General Applications Division

Committee on Marine Transportation (*J. B. Feder, Chairman; W. E. Jacobsen, Vice-Chairman; W. N. Zippler, Secretary*). A meeting of the committee was held on May 11, 1951. At this meeting it was decided that the extensive additions, clarifications, and revisions agreed upon since the 1948 edition of Standard *45*, "Recommended Practice for Electrical Installations on Shipboard," should be compiled and submitted to the Standards Committee of the Institute for approval. The decision was made at this time as it was believed desirable to issue a revised edition complete in itself rather than issue a lengthy addendum requiring extensive correlation with the 1948 edition. The principal changes in the proposed new edition cover: safety provisions for motor-generator sets; simplified and standardized recommendations covering storage batteries; clarified recommendations for generator switchboard equipment; rationalized recommendations for circuit overcurrent protection; greater safety in and simpler installations of motor controllers; improved lighting installations; clarified recommendations for fire alarm systems; recommendations covering marine-type transformers; cable installations in line with presently accepted practice; clarified electric propulsion equipment recommendations; rationalized cable current carrying capacities; and corrected cable dimensions and weights. The revised edition has been submitted to the Institute, and it is hoped will be available to the public by the beginning of 1952.

The committee has compiled data on subjects of interest to those concerned in marine electrical fields, which are inherently not suitable for inclusion in an Institute Standard, such as the latest requirements of the Suez Canal authorities for special lights. Information on such subjects will be supplied on request when available.

Liaison with other committees of the Institute—Rotating Machinery, and Instruments and Measurements—was provided to insure co-ordinated action in the marine field with the general policies of the Institute.

The next meeting of the committee will be held in the fall of 1951.

Power Division

Committee on Relays (*A. J. McConnell, Chairman; W. E. Marter, Vice-Chairman; Frank von Roeschlaub, Secretary*). The first meeting of the committee for the 1951–52 season was held in Detroit on September 26 and 27, with an agenda calling for a continuation of projects already under way and the initiation of new ones.

During the past year, seven *Transactions* papers and three conference papers sponsored by the committee were presented at four regular meetings. The report of the Project Committee on Generator Protection, presented at the Winter Meeting and published in the *Transactions*, culminates a study that has been in progress for the past three years. The Project Committee on Relay Bibliographies published its report, constituting a bibliography covering the three years 1947–48–49, and is currently at work preparing the 1950 version.

A paper on distribution circuit protection is nearing completion, and questionnaires have been distributed on various subjects including remote tripping, backup relaying, effect of vibration and shock on relays, and pilot wires. Project committees are busy with the accumulation and analysis of the answers to these questionnaires, which will serve as the basis for future reports.

The committee has maintained representation on other groups in allied fields. These include committees working on the National Electrical Manufacturers Association projected standards for relays and on the study of transient behavior of capacitance potential devices, undertaken by the Instrument Transformer Committee, and reported at the Toronto meeting in June.

Committee on System Engineering (*Robert Brandt, Chairman; H. L. Harrington, Vice-Chairman; O. W. Manz, Jr., Secretary*). The Committee held its annual spring all-day planning meeting on May 3rd in Chicago. At this time the System Controls Subcommittee was requested to compile a summary report of the interesting conference papers presented at New York in January on the subject, "Determination of What Units and What Plants Should Be Used for Load and Frequency Control." This summary report is to be available for publication in the *Transactions* so that the important considerations of these conference papers may be available to those who are interested.

An interesting group of papers on the subject of "Voltage Control" was presented under the sponsorship of the System Operation Subcommittee at the Summer Meeting in Toronto in June.

The System Economics Subcommittee arranged two co-ordinated technical sessions at the Fall Meeting in Cleveland on the various phases of "Economic Comparison of Alternative Facilities," which was of great interest to all concerned with economic comparisons for system planning purposes.

A meeting of the Committee on System Engineering was held during the Fall Meeting.

Science and Electronics Division

Committee on Basic Sciences (*M. G. Malti, Chairman; R. M. Bozorth, Vice-Chairman; W. C. Johnson, Secretary*). This committee established a new Subcommittee on Dielectrics during the past year. The scope of the new subcommittee covers the theory and properties of solid dielectrics, and its object is to serve the profession by acquainting the membership with new developments in its field. This has necessitated the restriction of the activities of the Committee on Electrical Properties of Solids to the field of Semiconductors and Transistors.

The committee voted establishment of a Subcommittee on Defense whose object would be to serve our country in the technical problems of the Armed Forces. It was learned, however, that the military establishment submits all its problems to the National Defense Council. The chairman has been in communication with this council in order to ascertain the most effective way in which our committee could render its co-operation.

Conferences were sponsored by the various subcommittees of the Committee on Basic Sciences. These included conferences on Magnetics, Transistors, Circuit Analysis and Energy Sources, and on the Electric Properties of Gases.

Committee on Electrical Techniques in Medicine and Biology (*S. Reid Warren, Jr. Chairman; A. M. Zarem, Vice-Chairman; Scott W. Smith, Secretary*). This committee was established as a technical committee on August 1, 1951, by combining the

ersonnel and the activities of the Committee n Therapeutics and the Joint Subcommittee n Electrical Aids to Medicine. The first najor activity of the committee has been ssistance in the formulation of the program or the Fourth Annual Conference on Electronic Instrumentation in Nucleonics nd Medicine, the planning committee for which is headed by Dr. J. D. Tebo. The Committee plans to hold its first meeting in New York on January 24, 1952. Tentative plans also have been made for the committee to sponsor a session at the Summer General Meeting in Minneapolis and at the Pacific General Meeting at Phoenix, Arizona, during 1952.

AIEE PERSONALITIES.....

H. L. Palmer (A '42), division engineer, con-rol divisions' electronics and regulator engi-eering division, General Electric Company, Schenectady, N.Y., has been appointed assist-ant to the manager of engineering of the con-rol divisions. Mr. Palmer joined the com-any in 1925 on the company's Test Course and in 1927 began work on vacuum-tube application development in the radio engi-eering division. He was transferred to the ndustrial control division in 1930. In 1940 Mr. Palmer was made engineer of the elec-ronic control section, and he was appointed division engineer in 1948. He served the Institute on the Electronics Committee (1944–50), and the Industrial Controls Com-mittee (1946–51). **Benjamin Cooper** (A 45), assistant division engineer, General Electric Company, Schenectady, N.Y., has been appointed division engineer, electron-cs and regulator engineering division, to ucceed Mr. Palmer. Mr. Cooper became associated with the company in 1937 and was assigned to work on special projects in he electronic control section in 1941. In 1945 he became a line engineer in the elec-ronic motor control group and in 1950 ne was appointed assistant division engineer.

. R. Hines (A '45), manager, Michigan Sales District, General Electric Company, Detroit, Mich., has been appointed assistant manager of marketing with headquarters in he company's New York City office. Mr. Hines joined the company in 1921 as a stu-dent engineer, and following service in the company's a-c engineering and central station divisions, he was appointed a sales engineer n 1925. He is a member of The American Society of Mechanical Engineers and Tau Beta Pi. **C. M. Dunn** (A '42), assistant district manager, General Electric Company, Detroit, Mich., has been appointed manager f the district to succeed Mr. Hines. He has been a General Electric sales representative n the Midwest since 1932. He was named ssistant manager in the Michigan district in 949. Mr. Dunn is a member of Tau Beta Pi.

. W. McNairy (A '26), manager of engineer-ng and manufacturing, Appliance and Merchandise Department, General Electric Company, Bridgeport, Conn., has been ap-ointed manager of the company's Appliance Park project at Louisville, Ky. Mr. McNairy entered the service of General Electric in 1917, and after serving with the United States Army in World War I he be-ame a member of the control division of the Railway Department. In 1928 he was ap-ointed assistant design engineer of the control division. In 1940 he was transferred to Bridgeport as assistant to the works manager in charge of engineering. In 1948 he was appointed manager of engineering and manufacturing.

G. W. Thaxton (M '36, F '43), Owner and general manager, Thaxton Engineering and Construction Company, Fredericktown, Mo., has been named regional engineer with the Power Supply Division of Defense Electric Power Administration. Before engaging in private practice Mr. Thaxton was associated with the General Cable Corporation as rural distribution manager. His experience previous to that included association with the Rural Electrification Administration, Tennessee Valley Authority, and with the Westinghouse Electric Corporation. He served the AIEE on the Power Transmission and Distribution Committee (1944–45). He is a member of Tau Beta Pi.

A. W. Friend (A '33, M '39), research engineer, Radio Corporation of America Laboratories, Princeton, N.J., has been appointed director of engineering, Instrument Division, Daystrom, Inc., Elizabeth, N.J. Dr. Friend received a bachelor of science degree in electrical engineering and a master's degree in physics from West Virginia University, and a doctor of science degree in communications engineering from Harvard University. The author of several technical publications, Dr. Friend holds many patents in the electronics field. He has served the Institute on the Education Committee since 1949.

K. P. Applegate (A '14, Member for Life), Executive Vice-President, Hartford Electric Light Company, Hartford, Conn., has been elected President of the company. Mr. Applegate has been associated with the company since 1912 when he began as an electrical engineer. He later became a power salesman, and in 1916 was made purchasing agent. Thirteen years later he was appointed general manager and in 1943 Vice-President. He served the Institute on the Management Committee (1947–51).

E. W. Knapp (A '31, M '44), superintendent, system planning division, **J. M. Crawford** (A '31, M '45), assistant superintendent, system planning division, and **J. A. Smith** (A '44), assistant superintendent, system operating division, all of The Shawinigan Water and Power Company, Montreal, Quebec, Canada, have been appointed to the following positions: chief electrical engineer, superintendent, system planning division, and superintendent, system operating division. Mr. Knapp has served the AIEE on the Protective Devices Committee (1947–49).

J. R. MacGregor (A '23, F '39), chief engineer, The Bell Telephone Company of Pennsylvania, Pittsburgh, Pa., has retired. He was born on August 30, 1886, in Fort Collins, Colo., and was graduated from the Colorado State College of Agriculture and Mechanical Arts in 1908 with a degree of bachelor of science in mechanical engineering. He began his telephone career with the Western Electric Company, Inc., Chicago, Ill., in 1909, as a student engineer. In 1913 Mr. MacGregor transferred to The Bell Telephone Company of Pennsylvania, and four years later he was made equipment engineer in the General Engineering Department. There he became closely associated with the introduction of the panel dial system in Philadelphia and Pittsburgh. Mr. MacGregor became chief engineer at Pittsburgh in 1926 and since that time has directed engineering activities at that location. He was served the Institute on the Communications Committee (1932–42), and the Membership Committee (1934–38). **E. W. Baker** (A '40, F '51), plant extension engineer, American Telephone and Telegraph Company, New York, N. Y., has been appointed to succeed Mr. MacGregor as chief engineer. Mr. Baker is a graduate of Lehigh University from which he received a degree of electrical engineer in 1924, and the same year he became associated with The Bell Telephone Company of Pennsylvania. He worked on toll cable design, becoming plant transmission engineer in 1929. The following year he was transferred to the American Telephone and Telegraph Company in New York as engineer, Operation and Engineering Department. In 1950 Mr. Baker was appointed plant extension engineer.

C. B. Jolliffe (M '34, F '49), Executive Vice-President, RCA Laboratories, Radio Corporation of America, Princeton, N. J., has been elected to the position of Vice-President and Technical Director of the Radio Corporation of America. Dr. Jolliffe has served as Executive Vice-President in charge of the RCA Laboratories Division since 1945. **E. W. Engstrom** (F '49), Vice-President in charge of research, RCA Laboratories, will succeed Dr. Jolliffe as Vice-President in charge of the RCA Laboratories Division. Dr. Jolliffe has served actively on the following AIEE committees: Communication (1934–39, 1944–47, Chairman 1936–37); Technical Program (1936–37); Lamme Medal (1949–51).

G. W. Penney (A '26, F '45), George Westinghouse Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa., has been voted a John Price Wetherill Medal by The Franklin Institute for his "work in the development of a practical and commercially used electronic precipitator to remove particles of matter from ventilating air." Mr. Penney became associated with Westinghouse in 1923, first as a research engineer, later as manager of

the Electrophysics Department. He also worked in a civilian capacity with the Atomic Energy Commission, the Office of Scientific Research and Development, and the United States Army. He became the George Westinghouse Professor of Engineering at Carnegie Institute of Technology in 1947. He is the author of many technical papers and holds membership in Tau Beta Pi, Sigma Xi, Eta Kappa Nu, the American Physical Society, and the American Society of Heating and Ventilating Engineers. He has actively served the AIEE on the following committees: Basic Sciences (1937–47); Research (1941–45); Electronics (1945–51).

C. M. Foust (A '22, F '47), division engineer, General Engineering and Consulting Laboratory, General Electric Company, Schenectady, N. Y., has been awarded a Howard N. Potts Medal by The Franklin Institute "in recognition of his many contributions to the knowledge of high-voltage surge phenomena and the quantitative measurements furthering this knowledge through his development of accurate measuring devices." Mr. Foust served in the United States Army during World War I and later received his bachelor of science degree from the Carnegie Institute of Technology. Following graduation he became associated with General Electric where he began his work on high voltages and insulation. In 1928 he was appointed section engineer in charge of high-voltage and surge measurements, and in 1945 he became division engineer of the high-voltage and nucleonics division. He is a member of the American Standards Association and Sigma Xi. He has served on the AIEE Membership Committee (1937–40).

E. A. Gaugler (A '44, M '47), chief, magnetic materials subdivision, Naval Ordnance Laboratory, White Oak, Md., has been appointed Vice-President and Director of Research, Magnetics, Inc., Butler, Pa. Dr. Gaugler received his bachelor of science degree from the University of Michigan (1940), his master of science in physics from the California Institute of Technology (1947), and his doctor of philosophy degree in physics from the University of Maryland (1950). He joined the Naval Ordnance Laboratory in 1941. Dr. Gaugler is also a member of the American Physical Society and Sigma Xi, and he has served on the AIEE Basic Sciences Committee (1948–50).

C. F. Terrell (A '10, F '46, Member for Life), Vice-President, Puget Sound Power and Light Company, Seattle, Wash., has been appointed general manager, Ebasco Services, Inc., in Greece, where the firm is executing a contract to manage the design, construction, and operation of a modern power system. Mr. Terrell had been associated with the Puget Sound Power and Light Company for 25 years, the last nine of which he was Vice-President in charge of operation and engineering. He served the Institute as Vice-President of North West District (Number 9) (1946–48), and is currently serving on the Production and Application of Light Committee.

C. W. Miller (A '42), design engineer, Westinghouse Electric Corporation, Sharon, Pa., has been named manager of engineering of the large power transformer section at Sharon. Mr. Miller became associated with Westinghouse in 1928 after receiving a bachelor of science degree in electrical engineering from the University of Idaho. In 1948 he was appointed supervising engineer in the large power transformer section, and in 1949 was named section manager in charge of the shell form section. Mr. Miller served on the AIEE Feedback Control Systems Committee (1949–51).

B. M. Williams (A '50), research engineer, Magnolia Petroleum Company, Dallas, Tex., is now a sales engineer for the John A. Green Company, Dallas, Tex. Mr. Williams received a bachelor of science degree in electrical engineering in 1947 and a master of science in 1949 from Oklahoma Agricultural and Mechanical College, Stillwater, Okla., where he also taught electrical engineering for two years. He is a member of the Institute of Radio Engineers.

R. C. Machler (M '46), associate director of research, Leeds and Northrup Company, Philadelphia, Pa., has been appointed director of research of the company. Dr. Machler joined Leeds and Northrup in 1929 as a research engineer and physicist and became associate director of research in 1948. He is a member of Sigma Xi, American Physical Society, Optical Society of America, and the American Society for the Advancement of Science.

W. R. G. Baker (A '19, F '47), Vice-President, electronics division, General Electric Company, Syracuse, N. Y., has been awarded the Medal of Honor of the Institute of Radio Engineers (IRE) for his "early technical contributions to the radio transmitter art, his long sustained and effective leadership of institute and industry engineering groups and his outstanding service to the Institute." Dr. Baker is a member of the IRE Board of Directors.

W. F. Rauber (M '45), sales manager, switchgear divisions, General Electric Company, Philadelphia, Pa., has been named special representative of the General Electric large apparatus division, Washington, D. C. In his new position Mr. Rauber will direct his activities to liaison with governmental agencies created in connection with the national defense program. **C. E. Burke** (M '49), sales manager, specialty transformer and ballast divisions, General Electric Company, Fort Wayne, Ind., has been appointed to succeed Mr. Rauber in Philadelphia.

J. D. McCrumm (A '36, M '47), professor of electrical engineering, Swarthmore College, Swarthmore, Pa., has been appointed Chairman of the Division of Engineering. Dr. McCrumm has taught at Swarthmore College since 1939. Previous to his appointment there he served as test engineer at the General Electric Company, Schenectady, N.Y., and as research engineer at the Douglas Aircraft Company, Santa Monica, Calif. He holds several patents on devices for aircraft heating and anti-icing. Dr. McCrumm served on the AIEE Student Branches Committee (1948–49).

E. A. Williams, Jr. (A '37, M '42), engineer in charge, Electrical Apparatus Engineering Department, General Electric X-Ray Corporation, Milwaukee, Wis., has been appointed chief engineer, Railway and Industrial Engineering Company, Greensburg, Pa. Prior to three years in Milwaukee, Mr. Williams was with the General Electric Switchgear Division in Philadelphia, Pa., for 17 years where he served in various capacities.

A. L. Hough (M '43), assistant to the general superintendent, and **Donald King** (A '38, M '49), system operating engineer, both of The Shawinigan Water and Power Company, Shawinigan Falls, Quebec, Canada, have been appointed to the positions of assistant general superintendent and assistant superintendent respectively.

W. H. C. Beckett (A '49), district service representative, General Electric Company, Cleveland, Ohio, has been appointed district service supervisor for the company's Major Appliance Department in the Great Lakes District.

W. T. Rogers (A '28, M '42), safety consultant, Ebasco Services, Inc., New York, N.Y., has been made managing director of the Inter-American Safety Council. Mr. Rogers has served the AIEE on the Safety Committee since 1943.

E. H. Howell (A '42), sales manager, meter and instruments divisions, General Electric Company, Lynn, Mass., has been appointed manager of the East Central District of the company's Apparatus Marketing Division. Mr. Howell joined General Electric in 1922 as a student engineer.

OBITUARY...

Hervey Sackett Vassar (A '06, M '18, Member for Life), retired, Bloomfield, N. J., died on August 30, 1951. He was born on December 28, 1877, in Flemington, N. J., and in 1903 was graduated from Pratt Institute. Mr. Vassar had been continuously associated with the Public Service Electric and Gas Company, Newark, N. J., since 1903. He was made engineering assistant in 1905 and three years later he became assistant superintendent. In 191[illegible] Mr. Vassar became laboratory engineer which position he held until his retirement. He was a Fellow of the American Society for the Advancement of Science, past President of the American Society for Testing Materials, and Honorary Life Member of The American Society of Mechanical Engineers. He served on the following AIEE Committees: Electrophysics (1920–21); Instruments and Measurements (1920–25); and Standards (1947–50).

William Gordon James (M '40), manager, large power transformer engineering, transformer division, Westinghouse Electric Corporation, Sharon, Pa., died on August 10, 1951. He was born on December 12, 1889, in Powell, Nebr., and was graduated in 1913 from Kansas State College, with a bachelor of science degree in electrical engineering. After serving as a student engineer with the General Electric Company, he was appointed an instructor in the Electrical Engineering Department at the University of Maine, Orono, Me., and later he was made assistant professor of electrical engineering at the Agricultural and Mechanical College of Texas, College Station, Tex. Mr. James joined Westinghouse in 1920 as a power transformer design engineer and in 1931 he became section manager. In 1940 he was named manager of large power transformer engineering. He served the Institute on the Transformer Committee (1948-51).

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of September 20, 1951, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Fellow

Almon, C. P., Jr., chief, power system operations branch, Tennessee Valley Authority, Chattanooga, Tenn.
Bathe, C. E., transmission & distribution supt., Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Bedford, B. D., section engr., General Electric Co., Schenectady, N. Y.
Blake, D. K., mgr., power transmission & distribution section, General Electric Co., Schenectady, N. Y.
Bloomquist, W. C., industrial power application engr., General Electric Co., Schenectady, N. Y.
Boice, W. K., application engr., General Electric Co., New Haven, Conn.
Bowman, K. K., asst. mgr. of engg., General Electric Co., Schenectady, N. Y.
Brainard, D. E., div. engr., General Electric Co., Schenectady, N. Y.
Buell, R. C., mgr. sponsor div., General Electric Co., Schenectady, N. Y.
Crever, F. E., div. engr., General Electric Co., Schenectady, N. Y.
Denny, W. M., mgr., service engg. divs., General Electric Co., Schenectady, N. Y.
Fairman, F. E., Jr., general sales mgr., large apparatus div., General Electric Co., Schenectady, N. Y.
Ferguson, R., elec. engr., Association of American Railroads, Chicago, Ill.
Garr, D. E., div. engr., electro-mechanical div., General Electric Co., Schenectady, N. Y.
Gaston, J. R., consulting engr., 213 Locust St., Harrisburg, Pa.
Halberg, M. N., application engr., General Electric Co., Schenectady, N. Y.
Hooke, R. G., transmission planning engr., Public Service Electric & Gas Co., Newark, N. J.
Ide, C. E., pres., The Toledo Edison Co., Toledo, Ohio
Kaar, I. J., engg. mgr., electronics dept., General Electric Co., Syracuse, N. Y.
Kron, G., consulting engr., General Electric Co., Schenectady, N. Y.
Lord, H. W., research assoc., General Electric Co., The Knolls, Schenectady, N. Y.
Lorraine, R. G., application engg., Knolls Atomic Power Lab., General Electric Co., Schenectady, N. Y.
McEachron, K. B., Jr., mgr., technical education div., General Electric Co., Schenectady, N. Y.
McLachlan, W. J., mgr., central station engg. divs., General Electric Co., Schenectady, N. Y.
Morton, L. W., mgr., power electronics div., General Electric Co., Schenectady, N. Y.
Moyer, E. E., assoc. prof. of elec. engg., Rensselaer Polytechnic Institute, Troy, N. Y.
Pollard, E. I., chief elec. engr., Elliott Co., Ridgway, Pa.
Price, L. D., mgr., engg. & safety regulations dept., National Electrical Manufacturers Assn., New York, N. Y.
Puchstein, A. F., consulting engr., The Jeffrey Mfgr. Co., Columbus, Ohio
Rader, L. T., engg. mgr., control engg. divs., General Electric Co., Schenectady, N. Y.
Ryder, J. D., prof. & head, elec. engg. dept., University of Illinois, Urbana, Ill.
Sawyer, R. T., mgr., research dept., American Locomotive Co., New York, N. Y.
Schmidt, A., r., application engr., General Electric Co., Schenectady, N. Y.
Sebast, F. M., prof. & head, elec. engg. dept., Rensselaer Polytechnic Institute, Troy, N. Y.
Stemmons, B. L., elec. engr., Duke Power Co., Charlotte, N. C.
Taylor, W. H., regional power mgr., U. S. Bureau of Reclamation, Boulder City, Nev.
Van Antwerp, G. S., mgr., transmission & distribution dept., Philadelphia Electric Co., Philadelphia, Pa.
VerPlanck, D. W., head, mechanical engg. dept., Carnegie Institute of Technology, Pittsburgh, Pa.
Waidelich, D. L., elec. engg. prof., University of Missouri, Columbia, Mo.
Wischmeyer, C. R., assoc. prof. of elec. engg., Rice Institute, Houston, Tex.
Zimmerer, C. W., assoc. elec. engr., Underwriters' Laboratories, Inc., New York, N. Y.

41 to grade of Fellow

To Grade of Member

Adair, J. M., sales mgr., star-kimble motor div., Miehle Printing Press & Mfg. Co., Bloomfield, N. J.
Anderson, A. F., elec. engr., Boston Edison Co., Boston, Mass.
Angello, S. J., research engr., Westinghouse Research Laboratories, East Pittsburgh, Pa.
Angier, J. F., airways engr., Civil Aeronautics Administration, Washington, D. C.
Angle, W. P., dist. supt., power substation, Virginia Electric & Power Co., Richmond, Va.
Aubert, F., engr., control & research dept., Mexican Light & Power Co., Ltd., Mexico City, Mex.
Baily, P., substations supt., western div., The Ohio Power Co., Tiffin, Ohio
Balfour, H. T., Jr., div. engr., Louisiana Power & Light Co., West Monroe, La.
Barre, M. L., div. commercial engr., Southern Bell Tel. & Tel. Co., Jacksonville, Fla.
Barstow, J. M., member of technical staff, Bell Telephone Laboratories, Inc., New York, N. Y.
Battle, J. H., supervisor, elec. maintenance dept., Carbide & Carbon Chemicals Co., Oak Ridge, Tenn.
Beach, J. E., engr., Commonwealth Associates, Inc., Jackson, Mich.
Blair, R. W., elec. consultant, 3317 Emerson Ave., Parkersburg, W. Va.
Bonanno, J. L., chief engr., The Lionel Corp., Irvington, N. J.
Bonner, H. M., vice pres., Bonner & Barnewall, Inc., New York, N. Y.
Bosse, P. J., asst. supervising engr., Northern Indiana Public Service Co., Gary, Ind.
Bowser, R. V., junior engr., New England Power Service Co., Malden, Mass.
Brown, H. M., elec. engr., Maritime Administration, Washington, D. C.
Bruemer, H. H., Jr., design engr., Moloney Electric Co., St. Louis, Mo.
Burke, B. R., elec. design engr., Hughes Aircraft Co., Culver City, Calif.
Cohn, M., elec. engg. & serv. supervisor, Westinghouse Electric Corp., Baltimore, Md.
Conrad, I. F., application engr., General Electric Co., Washington, D. C.
Cooper, T. D., project engr., Engineer Research & Development Lab., Fort Belvoir, Va.
Crider, F. B., application engr., General Electric Co., Washington, D. C.
Davis, R. V., engr., General Electric Co., San Diego, Calif.
Duryee, S. L., senior engr., The Pacific Tel. & Tel. Co., Seattle, Wash.
Ehrke, L. F., fellow engr., Westinghouse Electric Corp., Bloomfield, N. J.
English, L. L., production engr., Louis Marx Co., Erie, Pa.
Eshelman, H. K., engr., Kansas City Power & Light Co., Kansas City, Mo.
Ferrara, P. D., senior design group engr., Consolidated Vultee Aircraft Corp., San Diego, Calif.
Field, H. M., supervising engr., New York Telephone Co., New York, N. Y.
Fraresso, M., asst. to director of engg., The Hydro-Electric Power Commission of Ontario, Toronto, Ont., Can.
Gallotte, W. A., engr., Puget Sound Power & Light Co., Seattle, Wash.
Gasparoli, R. E., product engr., General Electric Co., Schenectady, N. Y.
Grah, M. E., retired, 3309 River Road, Toledo 14, Ohio
Guiles, C. H., senior project engr., Sperry Gyroscope Co., Great Neck, N. Y.
Guy, G. E., section engr., General Electric Co., Cleveland, Ohio
Haak, A. E., div. engr., Louisiana Power & Light Co., Gretna, La.
Hawthorne, E. I., elec. engg. instructor, University of Pennsylvania, Philadelphia, Pa.
Heitkamp, I. H., underground engr., The Toledo Edison Co., Toledo, Ohio
Highleyman, C. D., asst. supt. of substations, Indiana & Michigan Electric Co., South Bend, Ind.
Hoag, R. O., elec. engr., Aluminum Co. of America, Massena, N. Y.
Hodson, H. O., vice pres.-operating mgr., Southwestern Public Service Co., Amarillo, Tex.
Hoefler, R. H., job foreman, National Cash Register Co., Dayton, Ohio
Horton, G. A., supervisor, engg. labs., Westinghouse Electric Corp., Cleveland, Ohio
Hudgins, W. D., engg. duty officer, USN., Washington, D. C.
Jacob, P. B., Jr., assoc. prof. of elec. engg., Mississippi State College, State College, Miss.
Jenkins, I. G., Jr., senior engr., Central Arizona Light & Power Co., Phoeniz, Ariz.
Jenkins, J. H., elec. engr. & estimator, Shelley Electric, Inc., Wichita, Kans.
Jensen, D. R., elec. engr., Geneva Steel Co., Salt Lake City, Utah
Lamperty, L., district elec. supervisor, Creole Petroleum Corp., Venezuela, S. A.
Lee, H. B., regional engr., Rural Electrification Administration, Washington, D. C.
Lengnick, L. W., engg. mgr., The Hawaiian Electric Co., Ltd., Honolulu, T. H.
Linke, S., asst. prof. of elec. engg., Cornell University, Ithaca, N. Y.
Lof, J. L. C., instructor, Massachusetts Institute of Technology, Cambridge, Mass.
Lyford, W. T., div. mgr., Florida Public Utilities Co., Marianna, Fla.
Marion, F. R., asst. supt., Western Electric Co., Inc. Kearny, N. J.
Marzolf, J. M., Jr., elec. engr., Naval Research Laboratory, Washington, D. C.
Maxwell, L. G., elec. engr., San Francisco Naval Shipyard, San Francisco, Calif.
McMurdo, C. E., engr., The Chesapeake & Potomac Telephone Co. of Virginia, Richmond, Va.
Meyer, J. H., engr., The Pacific Tel. & Tel. Co., San Francisco, Calif.
Miller, W. A., senior engr., The Pacific Tel. & Tel. Co., Los Angeles, Calif.
Moraweck, A. H., retired, 36 Woodland Road, Maplewood, N. J.
Murphy, D. M., senior elec. engr., Western Air Defense Force, Hamilton, Calif.
Nipper, E. E., design engr., The Kellex Corp., New York, N. Y.
Otten, A. J., maintenance supt., R. Herschel Mfg. Co., East Peoria, Ill.
Phillips, C. L., engr., General Electric Co., San Francisco, Calif.
Porter, R. G., program transmission engr., New England Tel. & Tel. Co., Boston, Mass.
Powell, P. T., elec. engg. supv., U. S. Rubber Co., Passaic, N. J.
Powers, H. B., central station sales engr., General Electric Co., Chicago, Ill.
Powers, R. I., system engr., Wisconsin Electric Power Co., Milwaukee, Wis.
Poynter, W. F., engg. representative, Pacific Electric Mfg. Corp., San Francisco, Calif.
Pritchard, F. H., elec. engr., General Electric Co., Erie, Pa.
Proctor, R. V., power apparatus specialist, General Electric Supply Corp., Salt Lake City, Utah
Reeves, F. E., elec. engr., Barnard & Burk, Baton Rouge, La.
Reinhard, J. W., elec. engr., dept. of water & power, City of Los Angeles, Los Angeles, Calif.
Schlegelmilch, R. O., electronic scientist, Rome Air Development Center, Griffiss AFB, Rome, N. Y.
Scott, R. B., engr., technical sales dept., General Electric S. A., Rio de Janeiro, Brazil, S. A.
Shafler, J. G., engg. draftsman, Atlantic Refining Co., Philadelphia, Pa.
Sheadel, J. M., development engr., Ohio Brass Co., Barberton, Ohio
Simpson, J. L., elec. engr., Carbide & Carbon Chemicals Corp., South Charleston, W. Va.
Stewart, R. B., staff engr., The Pacific Tel. & Tel. Co., Los Angeles, Calif.
Sweeny, J. O., transformer design engr., General Electric Co., Pittsfield, Mass.
Tallman, J. J., plant supt., Union Lumber Co., Fort Bragg, Calif.
Tamm, E. S., chief engr., kingston-conley div., The Hoover Co., Plainfield, N. J.
Tiedemann, J. J., Jr., div. construction supt., Louisiana Power & Light Co., Gretna, La.
Venner, M., engr., Metropolitan Vickers Electrical Co., Ltd., Manchester, England
Waltz, K. R., administrative engr., Douglas Aircraft Co., Long Beach, Calif.
Weems, J. H., Jr., area engr., Western Union Telegraph Co., St. Louis, Mo.
West, K. L., senior elec. engr., Cleveland Electric Illuminating Co., Cleveland, Ohio
Westgard, J. A., general engr., ordnance dev. lab., National Bureau of Standards, Washington, D. C.
Wilbur, B., mechanical design engr., General Electric Co., Schenectady, N. Y.
Williams, M., design engr., Westinghouse Electric Corp., Sharon, Pa.

94 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before November 25, 1951, or January 25, 1952, if the applicant resides outside of the United States, Canada, or Mexico.

To the Grade of Member

Chandler, F. H. (Re-election), The Hydro-Electric Power Comm., Toronto, Ont., Canada
Fujimoto, M., Sinko Electric Co., Toba, Mie-pref., Japan
McCullough, P. M. (Re-election), International Automatic Electric Corp., Chicago, Ill.

3 to grade of Member

OF CURRENT INTEREST

Communications Theme of Civil Defense Conference Held at Electronics Park

Some 280 Federal, state, county, and city officials, actively engaged in Civil Defense in all parts of the United States and Canada, attended a Civil Defense Conference at the General Electric Company's Electronics Park in Syracuse, N. Y., on September 13. Communications was the theme of the meeting and the various speakers emphasized the importance of a reliable network in the event of a disaster, whether caused by an atom bomb or by natural phenomena.

After a welcoming address by Dr. W. R. G. Baker, Vice-President and general manager of the General Electric Electronics Division, the program opened with a brief dramatic presentation, "Without Communication—A Nation Was Lost!" which illustrated the vital role of communications.

The first speaker, Colonel W. M. Talbot (retired), Director, Warning and Communication Division, Federal Civil Defense Administration, described the protective system now in effect and how this ties in with Civil Defense. This system consists of blankets of radar systems (not a protective ring, as commonly supposed) which cover the potential target areas of the country. These radars, supplemented by great numbers of volunteer ground observers, will locate and identify enemy planes and give the warning to a communications center. At this center messages are sent to interceptor groups, anti-aircraft units, and to Civil Defense units. The civilian unit will then further distribute the warning throughout its organization. With adequate communications facilities, the time lag is only a matter of seconds.

Another dramatic vignette, "Home Scene," followed and illustrated the need for adequate planning on a local level. With this mood set, Colonel H. S. Smith related his experiences as director of Civil Defense of Onondoga County, N. Y., and suggested means by which any local director can organize a communications system. The necessary steps would include soliciting the aid of local communications industries, such as telephone and telegraph companies; manufacturers and distributors of communications equipment; radio amateur groups; Boy Scouts; motorcycle clubs; and so forth. Other problems are organizing the existing facilities, establishing a competent communications technical advisory staff, complying with the Federal Communications Commission's rules, and coping with shifting directives and revised instructions from higher echelons.

The radiological aspects of Civil Defense were discussed by L. L. German of the Knolls Atomic Power Laboratory, who explained what immediate effects could be expected from an atomic bomb blast and what steps must be taken by Civil Defense workers. The first step after an atomic explosion is to determine the exact location of the center of the burst, then to establish the extent of radiation hazard so that rescue workers can proceed into the area without undue exposure. Mr. German described a novel device for locating the blast center. It is called a lampshade because of its shape, and it functions on the effect of shadows created by the heat and light of the explosion. Mounted at various locations around the target area, so there will be at least four units within 5,000 to 10,000 feet from a burst within the target area, a shadow will be cast on the inside surface of the metal lampshade. Wardens will be assigned to read these units, and readings from two or more units can establish ground zero and height of the explosion. The simplicity of this device makes it readily usable by nontechnical personnel.

The technical requirements for communications equipment for use in Civil Defense networks were discussed by L. W. Goostree, Jr., of the General Electric Company. A high degree of reliability is perhaps the most important requirement for such a system, as adequate communications must be maintained during a disaster if rescue operations are to proceed efficiently. In general, such a system would make use of available wire and radio facilities, using the two in parallel in the event that one or the other becomes defunct. Co-ordinating facilities would have to be provided between various services within a locality and also within larger areas. Parts of two frequency bands have been allocated for this purpose, one from 25–50 megacycles for long distances, and the other from 152–162 megacycles for local communications. Various types of mobile, portable, and stationary equipment could be used on these channels.

The actual design of a communications system as used in Syracuse, N. Y., was described by N. F. Harmon, Co-ordinator, Civil Defense, General Electric Company. The problem in this community, typical of most others, was to make as much use as possible of existing facilities. A dozen 2-way radio systems were found to be in use within the city, including police and fire departments, several taxicab companies,

Nerve center for Civil Defense operations in Syracuse, N. Y., is this communications center. This is a still from the movie "—and a Voice Shall Be Heard," filmed by the March of Time for the General Electric Company

Future Meetings of Other Societies

Audio Engineering Society. 3rd Annual Convention. November 1–3, 1951, Hotel New Yorker, New York, N. Y.

National Conference on Industrial Hydraulics. 7th Annual Conference. November 8–9, 1951, Sherman Hotel, Chicago, Ill.

National Electrical Manufacturers Association. November 12–15, 1951, Haddon Hall Hotel, Atlantic City, N. J.

National Research Council. 1951 Conference on Electrical Insulation. October 29–31, 1951, National Bureau of Standards, Washington, D. C.

Pennsylvania Electric Association. Fall Meeting, Prime Movers Committee. November 1–2, 1951, Fort Stanwix Hotel, Johnstown, Pa.

The American Society of Mechanical Engineers. Annual Meeting. November 25–30, 1951. Haddon Hall Hotel, Atlantic City, N. J.

The radiation "lampshade." Heat from an atom bomb blast would scorch the inside of the lampshade, but the brass rod in the center would cause a shadow from which the height of the blast and its ground zero can be determined

construction companies, and the local power utility. To co-ordinate these, a fixed base station with transmitter only was set up at the control center and inexpensive receivers were installed at the dispatch centers of the various services. In this way. information is sent to the dispatch centers, and from there to the proper mobile units. Thus each agency does its own dispatching.

At present each agency is being urged to install emergency power systems, and the suggestion has also been made to designate one of the mobile units as secondary base. Further insurance against failure has been made by providing a mobile unit as a secondary communications center. This unit, installed in a large trailer, contains equipment that duplicates that in the fixed communications center, but the trailer can be stored in a relatively safe place so that it is not likely to be damaged by bombing. This system of making maximum use of existing facilities and using relatively simple equipment to co-ordinate these is perhaps the most economical method of establishing a suitable network.

Major General F. H. Smith, Commanding General, Eastern Air Defense Force, was scheduled to give a talk on the effect of civilian participation on the results of military defense operations. However, he was unable to attend, and his talk was read by Brigadier General J. E. Smart. He stressed the fact that it is virtually impossible to build an impenetrable defense against air attack and that the so-called Maginot-Line type of defensive thinking has been abandoned. The air defenses are a compromise, designed to reserve as much strength as possible so that we can strike back at the enemy. Thus the civilian population must make every possible preparation to protect itself from the worst effects of atomic attack. Also, thousands of civilian volunteers must supplement the blanket of radar systems which cover the country, because the radar cannot identify types of planes, nor can it easily follow low-flying planes. Full co-operation between the Air Force and Civil Defense organizations is essential in maintaining our ability to fight.

One of the highlights of the conference was a March of Time movie sponsored by the General Electric Company which showed the organization of the Civil Defense communications network in Syracuse and, by simulating an actual disaster, how it would operate in an emergency. The film illustrated very dramatically the pressing need for organizing and putting into operation an effective communications network to direct rescue operations.

A demonstration of the mobile communications center also was given to show visitors at the conference what type of equipment can be used. Officials of the General Electric Company also pointed out that they have established a Technical Advisory Service which offers free technical advice to Civil Defense officials through their specially trained engineers located throughout the country.

First Supercharged Generator Installed at Wisconsin Power and Light Company

The installation of the first supercharged generator at the Edgewater plant of the Wisconsin Power and Light Company in Sheboygan, Wis., has been announced by the Allis-Chalmers Manufacturing Company, Milwaukee, Wis. This new design 60,000-kw 12,500-volt 3,600-rpm steam turbine driven generator was installed in midsummer and is now in operation. It embodies a new principle which saves 30 to 40 per cent of the material of a normal 60,000-kw machine.

The great reduction in weight and length is achieved by forcing hydrogen, at much higher velocity than has been used before, directly over the surfaces of the current-carrying copper conductors of the rotor. In addition to the normal fans for circulating the hydrogen, the new generator has a 2-stage centrifugal compressor, much like an oversize aircraft supercharger, mounted at one end of the rotor shaft supplying gas to the rotor. To get the heat out of the rotor faster, engineers have devised specially shaped copper windings through which cool hydrogen travels at high speed. After being heated in passing through the rotor, hydrogen is cooled by conventional water-to-hydrogen heat exchangers.

The heat removing ability of the supercharged design is demonstrated by test data showing that in less than 0.02 second hydrogen passes through the full length of the rotor passages of a 60,000-kw machine, while at the same time it absorbs enough heat to raise the temperature to 90 degrees Fahrenheit.

In addition to the great savings in copper and steel effected by the new design, several other very important advantages are brought about. Powerhouses of the future will be smaller and less costly, resulting from the shorter rotor and reduced rotor removal space required. Foundations will be simpler and reduced in size. Short-circuit currents are reduced substantially, with consequent savings in cost of circuit breakers, reactors, and other equipment, and with less damage likely to occur in event of short circuit.

The change from air to hydrogen cooling

The first supercharged generator, installed in midsummer at the Edgewater plant of the Wisconsin Power and Light Company, Sheboygan, Wis., and now in operation there, embodies a new principle which saves 30 to 40 per cent of the materials of a normal 60,000-kw machine. This new steam turbine driven generator is designated at 60,000 kw, 12,500 volts, 3,600 rpm

first introduced about 16 years ago and now universally used on machines of this type accomplished a 20 to 30 per cent boost in ratings for an equivalent frame size. By comparison, supercharged cooling in one step has raised generator ratings a further 70 per cent without any increase in amount of active material required. Future developments may well increase this gain.

Camera Records Mechanical and Electrical Story on Same Film

A modification of the Kodak high-speed camera which permits both the mechanical and electrical aspects of a subject to be recorded simultaneously on the same film has been announced by the Eastman Kodak Company, Rochester, N. Y.

The modification consists of the addition of a second lens to the camera to record the images on the tube of a cathode-ray oscillograph through the back of the film, while the mechanical aspects of the subject are being photographed on the front. This record will permit the photographer to present a complete picture of the behavior of electromechanical devices, and will also permit easy correlation with strain, acceleration, vibration, and other signals fed to the oscillograph in many nonelectrical problems.

Inasmuch as the film is traveling in a vertical direction the horizontal deflecting circuit alone is used. The film speed, as indicated by the edge-marking argon lamp in the Kodak high-speed camera, provides a time base if necessary.

Exposure of the oscillograph trace is continuous, not intermittent like the exposure of the picture image. On any given picture frame, the mid-point from top to bottom of the trace coincides with the mid-point of the exposure time of the picture image. The entire trace from top to bottom of the frame represents a time interval equal to the reciprocal of the picture frequency. This is five times the picture exposure time.

The trace may be placed at any desired position within the width of the picture field where it will not conflict with the subject matter to be photographed.

An oscilloscope providing a total accelerating potential of 10 kv or higher is recommended. A *P11* phosphor affords highest trace density, while a *P5* phosphor shows less tendency toward blurred traces in handling very high-speed transients. *P15* and *P16* phosphors are also useful for high-speed transients.

In use the oscilloscope is placed on a table or some other support to the left side of the camera.

New 2-lens high-speed Kodak camera for photographing simultaneously the operating mechanism of an electromechanical device and the trace on an oscilloscope showing the device's electrical functioning

New International Electrical Standards Recommended by IEC

Four new international electrical standards were recommended at the recent meetings of the International Electrotechnical Commission (IEC) in Estoril, Portugal. These standards cover: turbine-type generators; climatic and durability testing of electronic components for radio communication; power and distribution transformers; and rules for short-circuit conditions of large circuit breakers. The standards will now be submitted to the various national committees for approval. If approved by these committees, they will become IEC Recommendations and will be given world-wide distribution.

In addition, two recommendations previously approved by the national committees were put in final form and released for publication. They deal with a color code for fixed resistors, and a series of preferred values for radio receiving sets.

Fourteen countries were represented at the meetings by 153 delegates. The United States sent a delegation of 12 members.

New Plating Technique Puts Metal Surface on Plastics

A new and economical method of plating metal on Bakelite and Vinylite plastics makes possible lightweight, corrosion-resistant products with hard, high-polish metal surfaces. Metal-plated items molded of plastics cost less to ship than solid metal, are more resilient, lighter to carry, and are highly resistant to heat, abrasion, and weathering. New applications for metal-plated plastic articles are particularly useful for replacing metal parts in airplanes, trains, autos, luggage, and handbag accessories.

Mass production techniques, developed by the Plastiplate Company, Inc., South River, N. J., deposit a hard film of copper, silver, chromium, or other metal 0.002–0.003 inch thick on the surface of small plastic articles.

Twelve different colors as well as natural metal finishes can be plated evenly and to any desired thickness on styrene and phenolic plastics. Because of the high degree of control exercised during this mass electroplating process, even two colors can be plated on inner and outer surfaces of a single deep-molded plastic object to produce a unique inlay effect.

Sandblasting or wet and dry tumbling of the molded plastic object are the first of four basic steps of the electroplating process. This abrasive surface treatment roughens the smooth-molded plastic object to promote adhesion with the metal plating. As most plastics do not conduct electricity, a conductive bond coat then must be applied. Dipped for a minute or two in a sensitizing solution and rinsed, the plastic article is then given a thin bond coat of silver 10^{-8} inch thick by chemical reduction in a spraying or immersion operation. When dry, the bond coat is tested for electrical conductivity; 0.25 to 5 ohms is considered satisfactory.

Large numbers of roughened, bond-coated plastic items are then put in perforated barrels made of laminated plastics. These barrels revolve in a copper salt solution. Copper anodes furnish ions to the solution and these ions migrate through the barrel's perforations to plate out on the objects tumbling about inside. Contact for the cathode connection is made through the bottom of the barrel which is insulated from the solution by the high resistivity of the phenolic.

About 12 hours in the barrel are needed to build up a base coat of copper plate 0.002 inch thick on the plastic surface. A thin finish coat of gold, silver, chromium, nickel, brass, lead, and other metal or color then is plated over the copper base in another electroplating barrel to give the article the desired finish. In successive steps, deep-molded plastic articles can be inlaid with two different colors on inner and outer surfaces.

The strength and light weight of plastics makes possible the fourth and final step of mass polishing the small plastic articles

economically in tumbling barrels. The metal-plated plastic article bounces resiliently in revolving barrels containing steel shot and soap solution.

ISA to Hold Symposium on Boiler Instrumentation

The Philadelphia section of The Instrument Society of America (ISA) is sponsoring a symposium on boiler instrumentation to be held on Thursday, November 15, 1951, at the Bellevue-Stratford Hotel, Philadelphia, Pa. This will be an all-day conference with representatives of both instrument manufacturers and users presenting technical papers and discussions on various phases of this subject.

Technical chairman of the symposium will be Mr. A. W. Thorsen, Supervising Engineer, United Engineers, Philadelphia, Pa. The tentative technical program, to be given in morning and afternoon sessions, starts at 9:30 a.m. Each paper will be ollowed by prepared discussions by selected manufacturers and users.

Design of Instrumentation and Control in a Modern Power Plant. *T. T. Mullen*, Engineering Department, Gilbert Associates, Inc.

What the Boiler Designer Expects of Instrumentation. *H. C. Mittendorf*, Chief Electrical Engineer in Charge of Control Design, Combustion Engineering, Superheater, Inc.

Type of Combustion Control—Superheat and Reheat Controls. *E. D. Scutt*, in Charge of Steam Power Section, Leeds and Northrup Company

Modern Feed Water Control. *C. H. Barnard*, Application Engineer, Bailey Meter Company

At an evening session starting at 8 P.M., Mr. Mike Boho, Hagan Corporation, will talk on the subject of "Instrumentation for the Power Plant of the Future." The Industrial Instruments and Regulators Division of The American Society of Mechanical Engineers has been invited to attend this symposium and all guests interested in the general subject will be most welcome.

The registration fee of $2.00 per person will be charged for the morning and afternoon sessions; registration starts at 8:45 a.m.

EJC Membership Approves Affiliation with UPADI

The Engineers Joint Council (EJC) has received the approval of a majority of its member bodies to become an adherent of the Federation of Pan American Engineering Societies, known as UPADI from its Spanish name—Union Panamericana de Asociaciones de Ingenieros.

EJC has given enthusiastic support to the concept of a Pan American organization since its origin and participated in the first steps of its formation taken at Rio de Janeiro in July 1949, when the representatives of engineering societies in the Americas met in a First Pan American Engineering Congress. UPADI held its first meeting in Havana in 1951 (*EE, June '51, pp 558–9*) and agreed on a draft Constitution which was to govern until the next meeting to be held in New Orleans on August 25–30, 1952.

The United States is one of nine nations designated to furnish a member to the first UPADI Board of Directors. James M. Todd has been appointed as the United States Member of the UPADI Board and S. L. Tyler will represent the United States on the permanent UPADI Committee on Constitution and By-Laws.

Acting upon the invitation of the United States Delegates, the Havana UPADI convention decided to hold its next convention at New Orleans. This will permit delegates from other countries to take advantage of the trip to the United States to attend the Centennial of Engineering in Chicago immediately following.

First Mobile TV Caravan Built for U. S. Army Signal Corps

The United States Army Signal Corps now has its first television (TV) station on wheels. Construction of the unique mobile TV caravan by Radio Corporation of America (RCA), in close co-operation with engineers of the Signal Corps, was disclosed recently with delivery of the units to the Signal Corps' Fort Monmouth, N. J., Laboratories.

The caravan constitutes the most complete television station ever mounted on wheels. It consists of four special 10-ton trucks, each 31 feet long. Included in two of the trucks are complete TV transmitting and monitoring equipment, three TV field cameras, 10 receivers, a large-screen TV projector which will show life-size pictures, and a radio intercommunication system. The other two trucks contain power-supply generators.

According to the Signal Corps, the caravan will be used to explore the feasibility of television for field instruction, and to develop instructional techniques via TV. It is contemplated that the equipment might have much value in televising intricate field exercises and piping the picture to expert observers, maneuver umpires, or to classrooms.

New Glass Is Precision-Machined by Chemical Process

A new kind of glass which can be precision-machined through the use of ultraviolet light, heat, and hydrofluoric acid to form intricately cut patterns of any desired shape and depth has been developed by the Corning Glass Works, Corning, N. Y.

This new glass is the latest in a series of photosensitive compositions first announced by Corning in 1947 to produce permanent 3-dimensional photographs in glass in a variety of colors. To the new composition, which is a special kind of photosensitive opal glass, an equally new process of chemical machining has been adopted, which produces, without the aid of mechanical tools, lace-like patterns hitherto considered impossible in glass.

The first step in the process is the printing of a design in the glass, using an ordinary photographic negative and ultraviolet light. Development then is accomplished by heating the glass to 1,200 degrees Fahrenheit for the required length of time, usually about two hours. At this stage, a milk-white image appears in the otherwise transparent glass.

Next, the glass is immersed in a solution of hydrofluoric acid until the white areas are eaten through and removed, leaving the remaining unexposed glass in the exact form of the original pattern.

By varying the length and intensity of light exposure through the photographic negative, the depth of acid penetration in

New United States Signal Corps transmitting coach, which houses a complete TV transmitting studio, is equipped with a specially constructed operating desk for the portable monitoring, control, and power supply units used with the field TV cameras. The operating desk is mounted in the rear of the unit, facing large shatterproof glass windows which give a clear view of pickup activities outside

the glass can be accurately controlled from shallow etching to complete erosion. In this way, sculptured figures or contoured shapes can be made by using a continuous tone negative with proper degrees of shading.

Since chemical machining involves no mechanical stress, patterns, otherwise too complex to reproduce in glass or any other material without long and tedious work by skilled craftsmen, can be reproduced simultaneously in any number and with photographic accuracy.

Chemical machining is especially suited to perforating holes of any shape having diameters of only a few thousandths of an inch and numbering up to several thousands per square inch. Designs as irregular as lacework can be photoetched as readily as simple straight-line patterns.

The versatility of the process has already been demonstrated in the manufacture of printed electric circuits for electronic instruments. By using a photographic negative, in a single operation, a sheet of glass is cut into multiple pieces, each of proper shape and size, and each having identically etched circuit patterns and holes for fastening to a chassis. The pattern thus photoengraved in each piece of glass is filled with conducting metals to form an electric circuit of high precision and durability.

President of Japanese Science Council Confers in U. S.

Dr. Naoto Kameyama, President of the Science Council of Japan, conferred recently with Dr. A. T. Waterman, Director of the United States National Science Foundation, on the operation of a national science agency. Dr. Kameyama attended the International Congress on Pure and Applied Chemistry, which was held in New York, September 10–17. He was formerly Dean of Engineering at Tokyo University, and Director of the University Institute of Science and Technology.

The Science Council of Japan is older than the United States National Science Foundation, having been established by Japanese scientists in January 1949 as part of the program of reconstruction. At the close of the war, Japanese scientists, seriously depressed by the war's economic aftermath, conceived the idea of organizing a diet of Japanese scientists to represent the point of view of scientists at the national level.

The Council itself is made up of 210 members, elected to office by scientists of recognized qualifications and achievements throughout the nation. Membership is allocated evenly among seven divisions: 1. literature, philosophy, and history; 2. law and politics; 3. economics; 4. natural sciences; 5. engineering; 6. agriculture; and 7. medical sciences, including dentistry and pharmacy. The 30 members in each division are elected by colleagues in their own field.

The primary purpose of the Japanese Science Council is to encourage the development of science and its effective utilization by the government throughout every phase of national life. The Council advises the government on such matters as the distribution of government grants and subsidies for the promotion of scientific research, policies regarding the budgets and administration of governmental institutions and laboratories, and matters relating to the research programs and training of scientists in universities and their attached institutes.

Liaison between the Japanese Government and the Council is effected by the Scientific and Technical Administration Commission (STAC). Half of the 26 members are proposed to the Government by the Japanese Science Council, and the other half are Vice-Ministers of the cabinet. By means of STAC, the views of Japanese scientists are brought directly to bear on governmental problems.

Aerial Traffic Lights Aid Day and Night Refueling of Bombers

Busy street corners are not the only places to find traffic signals. They are also lighting up in the skies as Boeing *KB-29* and *KC-97* tanker airplanes refuel bombers in mid-air. They are used for both day and night in-flight refueling operations by the United States Air Force.

When the Boeing Flying Boom, through which the fuel is pumped to the receiver airplane, was first developed, directions from the boom operator to the receiver pilot were issued by radio only. But more recently the traffic lights have been installed on the bottom of the tankers to aid in keeping the two planes in the proper position while the fuel is being transferred.

The lights, four red and one green, automatically are triggered by microswitches connected with the boom. Lettering on the red-lighted oblong panels reads up, dwn, fwd, and aft, to advise the receiver pilot when his plane is out of position.

The new sealed beam lamp used in this application was developed for Boeing by the General Electric Company, Cleveland, Ohio.

When the telescoping section of the boom is extended to the proper length and the boom's elevation angle is correct, the green light glows, but should the airplane receiving fuel move outside of this position the green panel darkens and either one or two of the red lights flash on to tell the receiver pilot where to move.

$1,160,000 Pipeline Equipment Supplied by Westinghouse

Approximately $1,160,000 worth of electric equipment for a new 550-mile-long common carrier pipeline linking the West Texas fields with refineries and pipeline connections in the southern and eastern parts of the state will be supplied by Westinghouse Electric Corporation.

Five companies will pump crude oil from their production fields to a tank farm at Colorado City, where the first station of the new line will give the oil an 800-pound per square inch push through 134 miles of 26-inch line to Ranger. Booster pumps will add a like pressure to carry the oil another 142 miles to Wortham, about 60 miles south of Dallas. Here, the system will divide into a 114-mile, 20-inch line to Longview, and a 164-mile, 24-inch line to Lucas, near Beaumont.

The pipeline will have the latest refinements in motors for centrifugal pump drives, with centralized control automatically sequencing each pump motor through its associated valves and auxiliaries. It will feature the largest concentration of remote tank farm and pump manifold controls thus far centralized on a control console. The consoles will be of the piping-

New traffic lights are being installed on a Boeing tanker to direct the receiver pilot while in-flight refueling is in progress. The green center panel remains lighted when the two planes are in proper refueling contact. One or two of the four red panels flash on when they are not, instructing the pilot to move up, down, forward, or aft. Special sealed beam lamps were developed for this application by General Electric

iagram type, and one of them will control nore than 100 valves and 11 booster pumps.

Initially, three pumping stations will perate the system at about 300,000 barrels er day. Provision will be made for the uture addition of four intermediate stations, o increase the throughput to about 440,000 arrels per day.

BM Machine Provides Answers for Research Scientists

Development of a new electronic informaion-searching machine to help solve one of he most burdensome problems in scientific esearch was disclosed recently by International Business Machines Corporation (IBM).

Coupling electronic principles embodied n many of its standard electronic business nachines with a new machine language of 792 characters, IBM has developed an experimental full-scale working model that uses photoelectric eyes to read scientific nformation from IBM cards at the rate of 1,000 cards a minute.

Information contained in a book or an article or an abstract, or even a key paragraph, is condensed in terms of the new machine language. Then this condensed nformation is transferred into IBM cards. When information on a certain subject is deired, a question card is placed in the electronic scanning machine. The machine then proceeds to match the question and information cards, selecting those which give the answers or tell specifically where the answers can be found.

Selfocus Cathode-Ray Tube Put to Military Use

The new Selfocus Cathode-Ray Tube developed by the Allen B. Du Mont Laboratories, Inc., Clifton, N. J., has been used for military applications with satisfactory results. In addition to its simplification o design the new tube saves approximately three pounds of weight in airborne radar equipment.

The principle of selfocus permits the use of the cathode-ray tube which requires no focusing controls, no focusing coils, no permanent magnet focusing, or electrostatic focusing devices. When the Selfocus tube s employed in a television receiver or a radar unit, the picture requires no focus adjustments, regardless of line voltage variations or differences in brightness and contrast settings.

Savings in critical materials are greater than the electrostatic-type focusing tubes, while the over-all weight is cut by several pounds. Also, savings in cost are effected through the elimination of the focusing circuit, thus saving both component parts and assembly time.

New Trolleyphone Features Packaged Maintenance

A new development in mill and mine communications—a packaged maintenance idea—has been introduced by the Farmers Engineering and Manufacturing Company, Pittsburgh, Pa., in its Trolleyphone.

The Trolleyphone, which operates by feeding frequency-modulated carrier current into a plant's power system, now has its circuit packaged in plug-in components for a quick change by anyone in case of communication interruption.

The heart of the unit, the transreceiver containing the resistors and circuit, is now mechanical in make-up by using ten convenient component parts units that plug into octal sockets like radio tubes.

No technicians are needed; anyone can service the Trolleyphone by testing components down the line with like-numbered spare units until service is resumed.

Trolleyphones are used in mines to maintain constant contact between despatchers and locomotive operators, whether moving or stationary, and at loading points. In mills, they have been found useful on traveling cranes, ore bridges, charging and coke-oven machines, and locomotives. Using no signal wires, the Trolleyphone carries 2-way talk over existing electric circuits, whether a-c or d-c.

New Press Brake Has Electronic Control of Ram Motion

What is believed to be the first press brake ever to utilize photoelectric control of the "ram" motion has been constructed by the Verson Allsteel Press Company, Chicago, Ill.

Through use of the General Electric electronic system, the ram may be held completely level through its stroke, or may be operated at a preselected degree of tilt down to 0.001 inch.

The new press brake is operated hydraulically. The ram is actuated by two independent hydraulic cylinders supplied from separate matched pumps. A reversible booster hydraulic pump is used to transfer oil from one line to another to maintain position synchronization of the ends of the ram.

The booster pump is driven by a motor supplied by an amplidyne generator, which is controlled by the photoelectric system. Any tilt of the ram raises or lowers a barrier suspended between the photoelectric cell and the light source. Movement of this barrier as much as 0.001 inch results in automatic correction through altered speed and direction of the oil flow from the transfer pump.

Superfine Glass Fibers Can Be Used to Make Paper

Production of the finest glass fibers ever manufactured was announced recently by Glass Fibers, Inc., Toledo, Ohio. Diameters of these fibers are less than the shortest wavelength of visible light. A single pound of the fibers, laid end-to-end, would extend more than 10,000,000 miles.

Indicated uses for this amazing new material are myriad. From it, a glass paper has been manufactured on a Fourdrinier paper-making machine.

Such a glass paper opens up an entirely new field in the filtering of submicron dust and particles. Its efficiency in filtering particles as small as 10^{-7} inch is revolutionary. Tests have proved that the new glass paper filters out all but one particle from 100,000 particles.

The glass paper also appears to have widespread use in electric equipment. Impregnated with suitable resins, it will find use as insulating tape for wire and cable and other applications in motors, generators, and transformers.

Designers of power-type capacitors and condensers for electronic equipment and television and radio receivers will find new uses for this glass material. Capacitors and condensers made with thin glass paper will have lower electrical losses, greater high temperature stability, and greater capacitance per unit of weight and size than those made with present-day materials.

Miniature Electronic Units Developed for Jet Trainers

Engineers' experience with jet flight trainers and simulators at Link Aviation, Inc., Binghamton, N. Y., has led to new space-saving electronic developments and designs. The new units, which are smaller and cheaper, include a servo amplifier, summing amplifier, linear-phase detector, variable-frequency oscillator, audio amplifier, and phase detector.

Conservation of space was only one of the factors involved in the development of these miniaturized units. Undistorted signal reproduction, accuracy of computation and control, and unit interchangeability with no adjustment were primary considerations of the engineers who designed them. Advantages of these units are many. Productionwise, they are easier to produce and therefore cheaper. Components are assembled on strips as basic assemblies. Leads have been shortened and wiring of the chassis is limited to tube filaments.

Inspection and maintenance procedures are likewise affected. Production testing and adjusting require minimum technical skills. Units are tested against specified meter indications and for the most part adjustments are unnecessary. Servo units are preadjusted before installation.

Adjustments formerly made against whole trainer systems are now made against fixed standards. Knobs and adjustable potentiometers are virtually eliminated; also, the serviceman can carry several units in a small service kit for replacement.

Scarce Nickel to Be Replaced by Newly Developed Alloy

A development that may help replace strategically short nickel in the automotive and other industries was announced recently by the Du Pont Company's Electrochemicals Department. Through it a "white brass" alloy is used to replace nickel as a base for chromium finish. This process is now the subject of intensive research work in the company's laboratories and in manufacturers' plants to adapt it to current production demands. The company emphasized that there are still a number of technical obstacles to be overcome.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Rectifier-Type Motive Power

To the Editor:

I would like to add a few remarks to the article entitled "Rectifier-Type Power for Railroads" which appeared in *Electrical Engineering*.[1]

It might not be generally known in America that mercury-arc rectifier locomotives of B_0B_0 type weighing approximately 85 tons (metric) and having 1-hour ratings of 2,730 and 3,280 horsepower have been in regular service on the German State Railways since 1936, on the Höllentalbahn section, consisting of 36 route miles, 86 track miles, and operating on the standard industrial frequency of 50 cycles per second.

This same railway uses a locomotive of similar weight, horsepower, and type, having single-phase series motors supplied directly through the locomotive transformer from the 50-cycle overhead contact system.

Operating experience with these locomotives has demonstrated the superiority of the locomotive having 50-cycle single-phase motors. The French National Railways (SNCF), in conjunction with Messrs. Oerlikon, Ltd., of Switzerland, have developed and actually built a locomotive of the C_0C_0 type weighing approximately 100 tons (metric) and having six single-phase a-c traction motors for operation on 50 cycles, developing 730 horsepower (1-hour rating) each. This locomotive will operate on the line between Aix-les-Bains and Annecy to La Roche sur Foron, a route distance of 78 kilometers, having 2-per cent gradients.

The traction motors have already undergone tests at the manufacturing plant and the commutation has been described as satisfactory by M. Garreau.[2]

Complete details of this locomotive and also of the 1,560-horsepower single-phase 50-cycle motor cars built for the SNCF have been described by L. H. Leyvraz[3] and also in the Oerlikon bulletin.[4,5]

It appears that the chief merit of the mercury rectifier-type motive power now being developed in the United States is that it will enable conversion of existing d-c and Diesel-electric rolling stock for high-voltage a-c operation from an overhead contact system supplied from central stations employing standard industrial frequency. In all other cases the single-phase a-c motor in its modern design should be a better proposition.

REFERENCES

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2. Railway Electrification in Great Britain, C. M. Cock. Discussion by M. Garreau. *Proceedings*, Institution of Electrical Engineers (London, England), volume 97, March 1950, part 1A: Convention on Electric Railway Traction, number 1, page 24.

3. Electric Traction with Single-Phase 50-Cycle Current, L. H. Leyvraz. *Bulletin*, Association Suisse des Electriciens (Zurich, Switzerland), volume 41, number 20, 1950, pages 733–51.

4. The Development and Present State of Single-Phase 50 C/S Electric Traction, L. H. Leyvraz, C. Bodmer, P. Leyvraz, E. Peter. *Bulletin Oerlikon* (Zurich, Switzerland), number 285, August 1950, pages 9–38.

5. The 50 C/S 20-Kv Single-Phase Rolling Stock of the French National Railways (SNCF), L. H. Leyvraz. *Bulletin Oerlikon* (Zurich, Switzerland), number 285, August 1950, pages 1–9.

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(*Editor's Note:* Since Mr. Vincze's letter was first submitted, he has written that the C_0C_0 locomotive described was put into regular service on October 6, 1950, and that the driving performance is stated to be "at least as good as that of the 1,500-volt d-c locomotives." Revue Generale des Chemins de Fer (Paris, France), November 1950. The advantages of the 50-cycle-per-second locomotives are pointed out by M. M. Garreau in the Revue Generale de l'Electricité (Paris, France), volume 60, April 1951, page 125.)

To the Editor:

I take exception to the last paragraph of Mr. Vincze's letter in that in my opinion the chief merit of the mercury rectifier-type motive power is not that it will replace existing d-c and Diesel-electric rolling stock for high-voltage operation, but that it will enable the railroads which use alternating current to utilize the cheaper and more easily maintained d-c motor for all classes of electric traction in place of the present single-phase commutator motor. This motor, while giving excellent performance in high-speed work, is essentially a high-speed motor, and motive power having the mercury-arc rectifier can utilize the slower speed d-c motors, especially in slower speed heavy freight service. It also has attractive possibilities on railroads which have to operate over both 600-volt d-c third rail and overhead 11,000-volt a-c contact wire..

H. F. BROWN (F '47)

(New York, New Haven and Hartford Railroad,
New Haven, Conn.)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

AMERICAN SOCIETY FOR METALS, TRANSACTIONS, Volume 43, 1951. Published by the American Society for Metals, 7301 Euclid Avenue, Cleveland 3, Ohio. 1,245 pages, plus Index, illustrations, diagrams, charts, tables, 9¹/₄ by 6 inches, cloth, $10.00. Fifty papers, occupying some 1,200 pages, are reproduced in this current annual volume. The subject matter covers a considerable range: ferrous and nonferrous metallurgy and metallography; plating and metal coatings; working, shaping, and heat treating; high-temperature alloys and problems; metal testing; and the effect of various conditions on the properties of metals and alloys. Single papers deal with the structure of permanent magnet alloys, with iron ore smelting, and with the powder metallurgy of beryllium.

ANNUAL REPORT ON THE PROGRESS OF RUBBER TECHNOLOGY, Volume XIV, 1950. Edited by T. J. Drakeley, published by W. Heffer and Sons Ltd., Cambridge, England, for the Institution of the Rubber Industry, 12 Whitehall, London, S.W.1, England, 1951. 114 pages, charts, tables, 10 by 7¹/₄ inches, linen, £1. 1s. Beginning with an historical and statistical review, this report proceeds to deal briefly with the following: planting and production of raw rubber and related products; physics and chemistry of raw rubber and rubber-like substances; synthetic rubber; manufactured rubber products such as tires, cables and electric insulation, mechanical rubber goods, textile-rubber composites, and cellular rubber; machinery and appliances. There is a subject index and an author index to articles cited.

ARCHITECTURAL GRAPHIC STANDARDS. By C. G. Ramsey and H. R. Sleeper. Fourth edition. John Wiley and Sons, New York, N.Y.; Chapman and Hall, Ltd., London, England, 1951. 614 pages, illustrations, diagrams, charts, tables, 11³/₄ by 9¹/₄ inches, linen, $10.00. Designed to give architects, builders, draftsmen, civil engineers, and others interested in building the standards, facts, and data needed to deal with every type and phase of building. The fourth edition is 80 per cent larger, contains 368 new plates, 151 revised plates, and an extensive index with over 11,000 references. Data are included on all materials, fixtures, fittings, devices, equipment, accessories, utensils, furnishings, apparatus, machinery, supplies, and structural material.

ASTM BOOK OF STANDARDS, 1950 SUPPLEMENTS including Tentatives. Part 1. Ferrous Metals. 316 pages. Part 2. Non-Ferrous Metals. 223 pages. Part 3. Cement, Concrete, Ceramics, Thermal Insulation, Road Materials, Waterproofing, Soils. 350 pages. Part 4. Paint, Naval Stores, Wood, Adhesives, Paper, Shipping Containers. 340 pages. Part 5. Textiles, Soap, Fuels, Petroleum, Aromatic Hydrocarbons, Antifreezes, Water. 579 pages. Part 6. Electrical Insulation, Plastics, Rubber. 284 pages. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1950–1951. Illustrations, diagrams, charts, tables, 9 by 6 inches, paper, $21.00 for complete set; $3.50 each. These 1950 Supplements give in their latest approved form some 353 specifications, tests, and definitions which were either issued for the first time in 1950 or revised since the 1949 book. All subjects usually dealt with are covered except chemical analysis of metals.

ASTM STANDARDS ON GASEOUS FUELS, prepared by ASTM Committee D-3, April, 1951. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. 138 pages, illustrations, diagrams, charts, tables, 9 by 6 inches, paper, $1.75. This publication is a compilation of the latest ASTM methods of tests pertaining to gaseous fuels. It contains a method of sampling natural gas and one on the measurement of gaseous fuel samples. There are two methods of analyzing natural gases, one by the volumetric-chemical method and the other by the mass spectrometer. Three methods of testing the water vapor content, the calorific value, and the specific gravity of gaseous fuels are given.

ASTM STANDARDS ON METALLIC ELECTRICAL CONDUCTORS, sponsored by ASTM Committee B-1 on Wires for Electrical Conductors; Copper and Copper Alloys, Copper-Covered Steel, Aluminum, Iron and Steel. March 1951. Published by American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. 222 pages, diagrams, charts, tables, 9 by 6 inches, paper, $2.50. This publication contains the various ASTM standards and tentative specifications and methods of test pertaining to metals used as insulated and uninsulated electric conductors. Copper and copper alloys, copper-covered steel, aluminum, galvanized steel core wire and other galvanized iron and steel wire are among the metals included. General test methods are given for the determination of resistivity of electric conductor materials, tension testing of metallic materials, and

ckwell hardness and superficial hardness of metallic terials.

SIC ELECTRON TUBES. (McGraw-Hill Electical and Electronic Engineering Series). By D. V. ppert. McGraw-Hill Book Company, New York, Y.; Toronto, Ontario, Canada; London, England, 51. 332 pages, illustrations, diagrams, charts, les, $9^1/_4$ by $6^1/_4$ inches, cloth, $5.00. Designed for in a first course in electronics, this text covers the ysical characteristics, electrical characteristics, theory, d mathematics of the 11 most basic types of electron es used in engineering. The book covers only the es themselves and not the circuit applications in ich they are used. Atomic theory and electron listics are covered as an integral part of the theory each tube and gradually enlarged and developed. course in a-c circuits is indicated as parallel or prequisite study.

BLIOGRAPHY OF ELECTRON MICROSCOPY. ited by V. E. Cosslett for the Institute of Physics, ngmans, Green and Company, New York, N. Y.; ward Arnold and Company, London, England, 1950.) pages, $8^3/_4$ by $5^1/_2$ inches, cloth, $7.50. This liography contains some 2,500 references covering relevant literature through 1948. The references arranged alphabetically by author. No subject lex is included. Short abstracts are provided for st of the references.

) BIBLIOGRAPHY OF STATISTICAL QUALITY ONTROL. Supplement. By G. I. Butterbaugh. iversity of Washington Press, Seattle, Wash., 1951. l pages, 9 by 6 inches, paper, $2.00. A supplement the 1946 "Bibliography of Statistical Quality Conl," this volume covers the period from 1946 through ne 1949 and lists approximately 725 items. It conns references to periodical literature, manuals, monoaphs, pamphlets, and books on such topics as sampling, rrelation, significance tests, design of experiments, alysis of variance, the theory of runs, frequency distritions, control charts, inspection, and probability. thor and subject indexes to both the original bibliogphy and this supplement are included.

JILDING FOR INVESTMENT. By C. H. Cowgill. einhold Publishing Corporation, New York, N.Y., 51. 482 pages, diagrams, charts, tables, 9 by 6 inches, th, $7.00. This book, written largely from the invess point of view, is of such broad scope that it will inter- builders and contractors, architects, and others in the lustry. It deals with commercial buildings, private d co-operative housing, and public and industrial ildings. Building design, construction, and equipnt are discussed as well as site selection. Management, modernization, appraisals, law, and ethics also are vered. A bibliography of books and relevant magae titles is included.

ITISH ELECTRICAL POWER CONVENTION, oceedings, 2nd, Harrowgate, 19–23 June, 1950. fices: 16 Stratford Place, London, W.1, England, 51. 350 pages, illustrations, diagrams, charts, maps, les, $8^3/_4$ by $5^1/_2$ inches, linen, 10s.6d. The five hnical papers presented in this volume of the proceedgs are concerned with the economics of electricity pply, advances in lamps and lighting, the operation of E.A. steam generating stations, the present and future boiler plants, and large modern steam turbogenerating nts. A list of visitors, delegates, and members, as well minutes of the general meeting and the Presidential dress, also are included.

OMMUNICATION NETWORKS AND LINES. W. J. Creamer. Harper and Brothers, New York, Y., 1951. 353 pages, diagrams, charts, tables, $9^1/_2$ by nches, linen, $6.00. Intended as a text for junior and ior electrical engineering students, the book provides mathematical treatment of communication networks d lines. The first part deals with network analysis d problems in the design of attenuators, filters, and ualizers. The second part contains the theory of mmunication lines with extensive applications to cables d open-wire circuits at audio and carrier frequencies. e final chapter presents the essential theory of the gh-frequency lossless line. A knowledge of telephone paratus and systems and of elementary hyperbolic nction theory is assumed.

OMPANY PROCEDURAL MANUAL ON EQUIPENT ANALYSIS. Published by William Kelly and mpany, 120 S. La Salle Street, Chicago, Ill., 1951. pages, charts, $11^1/_4$ by $8^1/_2$ inches, fabrikoid, $5.00. is manual provides basic instructions on a procedure determining the economic advantage of new equipnt, re-equipment or replacement, and plant exnsion. This practical publication by a management counselling firm is based on researches of the Machinery and Allied Products Institute and is supplementary to two more extensive publications of the Institute which discuss equipment policy and analysis.

DEVELOPMENT OF TESTS FOR EVALUATING RESEARCH PROFICIENCY IN PHYSICS AND CHEMISTRY, the fourth in a series of reports prepared under the sponsorship of the Manpower Branch, Human Resources Division, Office of Naval Research. American Institute for Research, Pittsburgh, Pa., April 1951. 36 pages, diagrams, 11 by $8^1/_2$ inches, paper, lithoprinted, apply. This fourth report describes a test development project undertaken as part of a comprehensive research program concerning the selection and evaluation of research personnel. Separate tests were developed for the fields of physics and chemistry. The technical test items evaluate proficiency in formulating problems and hypotheses, planning and designing the investigation, conducting the investigation, and interpreting research results. The nontechnical items cover proficiency in administering research projects and accepting organizational and personal responsibility.

DIELECTRIC BREAKDOWN OF SOLIDS (Monographs on the Physics and Chemistry of Materials). By S. Whitehead. Clarendon Press, Oxford, England; Oxford University Press, New York, N. Y., and London, England, 1951. 271 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_4$ inches, cloth, 25s. Of interest to engineers and experimental physicists, this book is a study of the electric strength of dielectrics. It covers the basic principles involved in the application of the physical theory of the solid state to the analysis of intrinsic electric strength and in the identification and examination of other forms of breakdown. Mathematical demonstrations are preceded by qualitative accounts, and experimental results and practical conclusions are summarized at intervals. References are given at the end of most chapters.

(THE) EARTH'S MAGNETISM. By S. Chapman. John Wiley and Sons, New York, N. Y.; Methuen and Company, London, England, 1951. 127 pages, diagrams, charts, tables, $6^3/_4$ by $4^1/_4$ inches, linen, $1.50. A brief but fairly broad account of our present knowledge of the earth's magnetic field and its changes, including solar and lunar daily variations, magnetic storms, and other irregular disturbances.

EINFÜHRUNG IN DIE THEORETISCHE GASDYNAMIK. By R. Sauer. Second edition. Springer-Verlag, Berlin, Göttingen, Heidelberg, Germany, 1951. 174 pages, illustrations, diagrams, charts, tables, 9 by 6 inches, paper, 16.50 DM. Written for engineers, this book provides a mathematical treatment of steady-flow of fluids moving with such high velocities that they no longer have a uniform viscosity. In addition to nonturbulent flow conditions, the characteristics of turbulent supersonic flow are presented as well as 3-dimensional problems which pertain to supersonic flow around moving bodies and wings.

ELECTRIC TRANSMISSION LINES, Distributed Constants, Theory and Applications. (McGraw-Hill Electrical and Electronic Engineering Series.) By H. H. Skilling. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1951. 438 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, fabrikoid, $6.50. Written as a text for both power and communication engineering students, this book presents the theory of circuits with distributed constants, valid at all frequencies. The theory is applied to radio-frequency lines, power lines, telephone lines, filters, and waveguides. A thorough knowledge of ordinary circuit theory involving lumped constants and of differential and integral calculus is assumed. Problems are given at the ends of the chapters, and the appendix contains useful tables and a list of references.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

ELECTRICAL INSULATION, Its Application to Shipboard Electrical Equipment. By G. L. Moses. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1951. 259 pages, illustrations, diagrams, charts, tables, 10 by $7^1/_2$ inches, cloth, $5.50. This manual provides data on insulation for rotating electric machines, emphasizing recent developments in the design and application of high-temperature insulation in ship construction. It begins with the basic concepts of electrical insulation and the classes and properties of insulating materials. Apparatus assembly, winding problems, finishes, testing, and maintenance are all discussed. A bibliography and list of navy insulating materials are included.

ELECTRONICS. (McGraw-Hill Electrical and Electronic Engineering Series.) By J. Millman and S. Seely. Second edition. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1951. 598 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $7.25. This fundamental course in electronics integrates physical concepts and engineering applications. It is designed to lay the groundwork for specialized courses in communications, electron-tube circuits, industrial electronics, and so forth. Major revisions in the new edition are in the material on cathode-ray tubes, the electron theory of matter, the kinetic theory of gases, electric discharges in gases, rectifiers, filters, and triodes as circuit elements. Appendixes provide necessary technical information.

ENGINEERING DESIGN. By J. E. Taylor and J. S. Wrigley. Third edition. Sir Isaac Pitman and Sons, Ltd., London, England, 1951. 137 pages, diagrams, charts, tables, $8^3/_4$ by 11 inches, cloth, 18s. This book links the fundamental principles of strength of materials and allied subjects with their application to the actual designing of simple machines or parts of machines. Proofs of fundamental formulae and illustrations of common engineering details are omitted, since they can be found in standard works. The recommendations of the British Standards Institution have been followed in the drawings.

ENGINEERING METALLURGY. By A. P. Gwiazdowski. C. C. Nelson Publishing Company, Appleton, Wis., 1950. 247 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $4.00. This text is designed to give the student, purchasing agent, production executive, and engineer basic metallurgical information about the nature and characteristics of the commercially important metallic elements and their alloys. Although information on nonferrous metals is included, the chief attention is given to ferrous metals. The objectives of the book are to present concise and clear definitions and principles, to provide information on the selection of materials and heat treatments, and to consider engineering specifications. Review questions and references are grouped at the end of the book.

HOSPITALS, INTEGRATED DESIGN. By I. Rosenfield. Second edition revised. Reinhold Publishing Corporation, New York, N. Y., 1951. 398 pages, illustrations, diagrams, charts, tables, 12 by $8^3/_4$ inches, linen, $15.00. This book integrates the latest information on hospital design with the latest information on hospital needs and facilities. Architectural considerations are discussed against a background of the problems peculiar to the hospital. Attention is given to the location and space requirements of the complex parts of the modern hospital as well as to the needs of specialized hospitals. Over 500 plans and photographs illustrate the text. Chapters on daylighting, artificial illumination, the mechanical plant, construction are included.

HYDRAULIC TRANSIENTS. (Engineering Societies Monographs Series.) By G. R. Rich. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1951. 260 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $6.00. Written for design engineers in the hydraulic and hydroelectric fields, this book applies arithmetic integration and trial-and-error arithmetic to the solution of a wide variety of problems in hydraulic transients. It not only furnishes a background for the arithmetic calculation of particular problems but also provides the essential mathematical foundation for the supporting theory. Important features are the integration tabulations and detailed analysis of surge tanks, and the numerical designs which can be assimilated and imitated in commercial practice.

INTEGRAL TRANSFORMS IN MATHEMATICAL PHYSICS. (Methuen's Monographs on Physical Subjects.) By C. J. Tranter. John Wiley and Sons, New

York, N. Y.; Methuen and Company, Ltd., London, England, 1951. 118 pages, diagrams, charts, tables, $6^3/_4$ by $4^1/_4$ inches, linen, $1.50. This book provides an outline of the use of integral transforms in obtaining solutions to problems governed by partial differential equations with assigned boundary and initial conditions. It also shows that a similar technique can be employed whatever the range of integration of the transform. Examples given in the book relate to radial flow of heat, heat conduction, the motion of a very long string, stresses in a long circular cylinder, and heat flow in a cylinder with radiation at the surface.

(AN) INTRODUCTION TO THE THEORY OF CONTROL IN MECHANICAL ENGINEERING. By R. H. Macmillan. Cambridge University Press, American Branch, 51 Madison Avenue, New York, N. Y.; London and Cambridge, England, 1951. 195 pages, diagrams, charts, tables, $10^3/_4$ by $7^1/_4$ inches, cloth, $6.00. This book explains the principles that underlie the action of automatic controls, servomechanisms, and regulators. The early chapters explain the principles of operation of all control systems; sufficient mathematics is then introduced to estimate the performance of any simple systems. In the last three chapters more advanced techniques are used to describe the methods used by control engineers. Linear differential equations are used in the first five chapters, and the theory of complex numbers and Laplace transformations is introduced before being used. A bibliography is included.

LINEAR COMPUTATIONS. By P. S. Dwyer. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1951. 344 pages, tables, $9^1/_4$ by 6 inches, cloth, $6.00. This book is written for those who have the general problem of finding numerical solutions for sets of simultaneous linear equations. It first describes the theorems and methods in terms of elementary algebra and then develops the subject by including introductory material on determinants and on matrices. More powerful expositions are included in the later chapters. Many illustrative problems aid in translating the mathematical results to concise calculation methods. Special emphasis is given to the general subject of the accumulation of errors when the computations involve approximate numbers. Reference lists follow each chapter.

LUBRICATION, ITS PRINCIPLES AND PRACTICE. By A. G. M. Michell. Blackie and Son, Ltd., London, England; Glasgow, Scotland, 1950. 317 pages, illustrations, diagrams, charts, tables, 10 by 7 inches, cloth, 35 shs. This book not only provides a general account of the subject but also includes essential data and factual information needed in daily practice. Following a consideration of physical properties and numerical constants of lubricants, the lubrication of sliding, thrust, journal, and rolling bearings and various other mechanisms is discussed. The distribution and treatment of lubricants in service are also considered. A list of references is included.

MATHEMATICAL SOLUTION OF ENGINEERING PROBLEMS. By J. Jennings. E. and F. N. Spon, Ltd., 22 Henrietta Street, London, W. C. 2, England, 1951. 208 pages, diagrams, charts, tables, 9 by $5^3/_4$ inches, cloth, 25s. This book has been particularly designed and written for the use of technicians who are familiar with basic mathematics but require guidance in effective practical application. Special features are the chapters on the construction of the nomogram, on statistical methods, and on dimensional analysis. The importance and utility of approximate methods of solution have been emphasized and practical illustrations given.

MECHANICS APPLIED TO VIBRATIONS AND BALANCING. By D. L. Thornton. Second edition. Chapman and Hall, Ltd., London, England, 1951. 584 pages, illustrations, diagrams, charts, tables, 10 by $6^1/_4$ inches, cloth, 50s. Written for engineers and physicists, this book presents the general theory of vibrations in its various aspects. This second edition contains a rewritten general survey and a new chapter dealing with the transmission of stress under conditions of rapidly applied loading, such as are encountered in the design of fortifications and structures to withstand the effects of explosions. Includes chapters on balancing of engines and locomotives, propagation of stress in elastic materials, beams and plates, rotating shafts and discs, and dynamic loading of structures.

MÉMENTO D'ÉLECTROTECHNIQUE. (Applications de l'Électricité, Volume V.) By A. Curchod, revised by L. Vellard. Second edition. Dunod, Paris, France, 1951. 621 pages, illustrations, diagrams, charts, tables, $8^1/_2$ by $5^1/_4$ inches, fabrikoid, 3,200 frs. INDEX ALPHABÉTIQUE DES CINQ TOMES. 79 pages, paper, 100 frs. The fifth and final volume of this set deals at considerable length with the group of applications broadly classified as light-current engineering (illumination, telephony, and telegraphy) and briefly with the special fields of radiology, electron optics, electrotherapy, and so forth. A separately issued alphabetical subject index is available covering this volume and the four earlier ones which deal with electrical principles and theory, d-c and a-c machinery, distribution and transmission, electric traction, and other heavy-current applications.

MOLESWORTH'S HANDBOOK OF ENGINEERING FORMULAE AND DATA. 34th Edition. Edited by A. P. Thurston. E. and F. N. Spon, Ltd., London, England, 1951. 1,672 pages, diagrams, charts, tables, $6^1/_2$ by 4 inches, cloth, $6.50. This comprehensive compilation of engineering information, formulae, and data has been completely revised, rewritten, and expanded to conform to the current requirements of the engineering profession. Section I (665 pages) covering the fundamentals of mathematics, mechanics, materials, physical data, and so forth, is followed by Sections II, civil and general engineering (540 pages), III, mechanical engineering (330 pages), and IV, electrical engineering (100 pages). A 50-page index provides effective access to the contained information.

MONTE CARLO METHOD. (Applied Mathematics Series Number 12.) United States Bureau of Standards, Washington, D. C., 1951. 42 pages, charts, tables, $10^1/_4$ by 8 inches, paper, $0.30, for sale by Government Printing Office, Washington 25, D. C. Thirteen papers and discussion are presented from the Symposium on the Monte Carlo Method, an interesting combination of sampling theory and numerical analysis. The method is a device for studying an artificial stochastic model of a physical or mathematical process, such as the random motions encountered in the field of statistical mechanics. The papers in this volume deal with current applications of the method and with random digits.

(THE) NATURE OF POLYPHASE INDUCTION MACHINES. By P. L. Alger. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1951. 397 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, linen, $7.50. The first three chapters of this text give familiar principles of analysis of circuits and magnetic fields. The next three include material on induction machine analysis, including design characteristics. In the following four chapters there is a good deal of new information on the calculation of resistance, torque relations, and magnetic noise. The rating and application of polyphase induction motors are discussed, and the final chapter explains Kron's generalized method of analysis and applies it to the solution of various induction machine problems.

NOMOGRAPHIC CHARTS. By C. A. Kulmann. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1951. 244 pages, diagrams, charts, tables, $10^1/_4$ by $7^1/_4$ inches, cloth, $6.50. Ninety-two nomographs are given for solving a variety of functional and general problems in such fields as hydraulics, mechanics, thermodynamics, and electrical engineering. Each chart occupies a full page and is accompanied by an explanation to aid in its use. The accuracy of the charts lies between ordinary slide-rule computation and exact numerical computation. Alignment, intersection, and combinations of intersection and alignment nomographs are the types given.

PRINCIPLES OF INDUSTRIAL MANAGEMENT. By L. P. Alford, revised and rewritten by H. R. Beatty. Ronald Press Company, New York, N. Y., 1951. 779 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, linen, $6.00. Completely rewritten and thoroughly modernized, this book presents the basic principles and methods used in the management of an industrial enterprise. Changes in this second edition include a new chapter on industrial leadership, a revised section on personnel administration, a new chapter on marketing the product, and expansion of the chapters on quality control and time and motion study to include the newer techniques. Questions for review, problems, and a selective bibliography follow each chapter.

PROBLEMS FOR THE NUMERICAL ANALYSIS OF THE FUTURE. (Applied Mathematics Series Number 15.) United States Bureau of Standards, Washington, D. C., 1951. 21 pages, diagrams, charts, $10^1/_4$ by 8 inches, paper, $0.20, for sale by Government Printing Office, Washington 25, D. C. This publication contains four papers which were presented at the 1948 Symposia on Modern Calculating Machinery and Numerical Methods. They deal with various aspects of numerical analysis in nonlinear mechanics, etc.

PAMPHLETS

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Annual Report of the National Bureau of Standards for 1950. Summarizing the scientific investigations conducted by the National Bureau of Standards (NBS), the report also contains accounts of current activities and more detailed descriptions of important scientific developments. The scope of research and development at the NBS, both theoretical and practical, is indicated by the names of the 13 scientific and technical divisions: electronics; atomic and radiation physics; chemistry; mechanics; organic and fibrous materials; metallurgy; applied mathematics; mineral products; building technology; heat and power; electricity and optics; metrology; and radio propagation. 113 pages, 28 illustrations, 50 cents per copy. Available from the Government Printing Office, Washington 25, D. C.

Radio Amateur's License Manual. 1951 edition of the manual covers the six classes of amateur license plus general information on amateur licensing, portable and mobile operation, overseas licensing, international regulations, and United States regulations. Each chapter on the individual licenses includes full information on the scope of the examinations. Also included is an examination schedule covering all Federal Communications Commission examination places and dates, a full-page map of United States amateur call areas, and a topical index. 96 pages, 50 cents per copy. Available from the American Radio Relay League, West Hartford, Conn.

Training by Television. This report presents the principal findings of an experimental study which compared training of Naval Reservists by live television with training by recorded TV and by standard classroom procedures. Training by television was found to be superior to standard classroom procedures. The report details the procedures followed to keep the tests objective. It concludes with a list of fundamentals that must be met if television is to be successfully exploited for rapid mass training. 24 pages, illustrated, 75 cents per copy. Available from the Office of Technical Services, United States Department of Commerce, Washington 25, D. C.

Bibliography on Ceramic Engineering. A bibliography listing more than 150 items under 15 classifications published by the Engineers' Council for Professional Development (ECPD). The bibliography is Section IV of a 7-part "Selected Bibliography of Engineering Subjects," prepared for the ECPD by the Institute of Ceramic Engineers as a guide. These bibliographies were prepared with the co-operation of teachers of technical subjects and professional engineers active in the fields covered by them. 8 pages. Copies obtainable for 25 cents each from Engineers' Council for Professional Development, 29 West 39th Street, New York 18, N. Y.

INDUSTRIAL NOTES ....

Westinghouse to Undertake $296,000,000 Expansion. The Board of Directors of the Westinghouse Electric Corporation has announced plans to undertake a $296,000,000 expansion program extending beyond 1953. The expansion program will be the second such program undertaken since the end of World War II. The first, announced in 1945, was completed in 1948 at a cost of approximately $150,000,000 and increased manufacturing facilities by 50 per cent. A special meeting of stockholders is scheduled in December at East Pittsburgh, Pa., to act on a proposal to increase the corporation's authorized debt from $150,000,000 to $500,000,000 in connection with this expansion program. It is the company's present intention to raise new capital through the sale of debt securities.

Acme Electric Enlarges Transformer Plant. A new wing providing approximately 7,000 square feet of floor space is being added to the dry-type air-cooled transformer plant of the Acme Electric Corporation at Cuba, N. Y.

Sylvania Election. Barton K. Wickstrum has been elected to the post of Vice-President and Director of Sales of Sylvania Electric Products, Inc. Charles A. Burton will succeed Mr. Wickstrum as general sales manager of the lighting division.

Two Firms to Study Commercial Isotope Production. The Atomic Energy Commission has accepted two proposals for private firms to study, at their own expense, the commercial feasibility of manufacturing, processing, and selling radioisotopes. Contracts have been signed with Bendix Aviation Corporation of Detroit, Mich., and Tracerlab, Inc., of Boston, Mass.

General Motors Opens New Technical Center. The General Motors Corporation has opened the office, shop, and dynamometer buildings of its engineering staff at their new technical center north of Detroit, Mich. The engineering staff, headed by Vice-President Charles A. Chayne, occupies the first of five building groups on the 813-acre site. Eventually the area will contain the corporation's research laboratories division, process development section, styling section, and a service center. The over-all project is expected to be completed in the next two or three years.

Bendix Forms Australian Affiliate. The Bendix Aviation Corporation has announced formation of a new affiliate, Bendix-Tecnico, Ltd., Marrickville, Australia. Bendix will hold a 40 per cent interest in the new firm and Tecnico, Ltd., will own a 60 per cent interest. Formed primarily to meet requirements of the Australian defense program and maintenance of United States commercial aircraft serving the Commonwealth, Bendix-Tecnico will manufacture and distribute aviation and industrial ignition equipment, aircraft starters and generators, carburetors, ground and airborne radio communications equipment, and radar and navigation equipment.

Westinghouse Appointments. Four production executives who will direct output of jet engine components and, later, electric home appliances at the new $20,000,000 Westinghouse Electric Corporation plant being built in Columbus, Ohio, are: C. L. Van Derau, general works manager; E. L. Smith, works manager; C. D. Heaton, manager of manufacturing; and John B. Roman, works engineer. Westinghouse also has announced the election of Edgar C. Dehne as assistant treasurer and assistant secretary. Mr. Dehne replaces Edward George, Jr., who is retiring after 45 years with the company.

H. K. Porter Buys Buffalo Steel Company. The H. K. Porter Company, Inc., of Pittsburgh, Pa. has acquired the Buffalo Steel Company, Tonawanda, N. Y., producers of light steel products, in a straight cash transaction. With the acquisition of this company and Conners Steel Company, Birmingham, Ala., Porter now has a total steel production capacity exceeding 200,000 tons per year.

Alcoa Expands Research Facilities. The Aluminum Company of America is expanding its research facilities with the erection of a new building at the company's aluminum research laboratories at New Kensington, Pa.

Outstanding Stock of Flexo Purchased by Copperweld. The Copperweld Steel Company, Glassport, Pa., has purchased all the outstanding stock of the Flexo Wire Company, Inc., of Oswego, N. Y. Flexo's production facilities will be utilized by Copperweld for the immediate production of small and fine sizes of wires and cables.

L. C. Kent of G-E Retires. L. C. Kent, illuminating engineer and dean of the General Electric Lighting Institute since its inception in 1923 at Nela Park, Cleveland, has retired.

Borg-Warner to Construct $3,000,000 Aviation Parts Plant. The Borg-Warner Corporation has announced plans for the construction of a $3,000,000 plant for the manufacture of electrically driven hydraulic and fuel pumps for jet engines at Wooster, Ohio.

Myer Fried Engaged by RCA Service Company. Myer Fried, retired United States Army Colonel with more than 20 years' experience in military and aviation electronics, has been engaged by the RCA Service Company as special advisor to P. B. Reed, Vice-President in charge of the government service division.

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Westinghouse Air Brake Acquires Melpar, Inc. Westinghouse Air Brake Company has acquired the entire capital stock of Melpar, Inc. Thomas Meloy, now President of Melpar, will continue in that same capacity and will retain his entire staff and organization.

Union Carbide and Carbon Appointment. Dr. James F. Eversole has been made manager of research administration of the Union Carbide and Carbon Corporation.

NEW PRODUCTS • •

Frequency Counter. The Hewlett-Packard Company, 395 Page Mill Road, Palo Alto, Calif., has introduced a new electronic measuring device which is the first single-unit commercial equipment capable of instantly measuring and displaying low, medium, and higher frequencies up to 10,000,000 cycles per second. The instrument, model *534A* Frequency Counter, offers two types of measurement. For determination of frequencies above 300 cycles per second, the equipment counts and displays the unknown directly on the front panel. To obtain these readings it is only necessary to connect the unknown to the instrument. A front panel switch selects five different counting periods—time intervals having an exact duration of 10, 1, 0.01, 0.001, and 0.0001 second. The instrument counts the frequency cycles occurring during the time interval thus selected, then displays the frequency numerically for an equal length of time. When switched to automatic operation, this cycle of counting and display is repeated indefinitely. However, any count may be held any desired length of time by pressing a manual button on the panel. For low-frequency work the instrument measures the period or duration of a cycle in microseconds. A 10-cycle sample is taken, and the duration of a cycle then is presented directly in microseconds. These duration measurements progress automatically through equal measuring and display periods as in direct frequency counting. Uses of the new counter include frequency measuring of transmitters and crystal oscillators, calibration of test oscillators, measurement of rpm, drift monitoring, crystal frequency checks, and measuring total random events per unit of time. It may be used also as a precision frequency standard, and to establish frequencies for filter characteristic determination. Complete data on the instrument may be obtained from the company.

Selenium Rectifier Power Units. The Syntron Company has announced development of new custom-made 50-kw and larger a-c to d-c rectifier power conversion units of high current and low voltage capacities. This new development has been made possible by the manufacture of extra-large selenium rectifier cells by Syntron's new

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and laboratory device for detecting and locating tiny leaks during the manufacture of electron tubes of all types, vacuum bottles, or any device large or small which can be evacuated, has been developed by the RCA Scientific Instrument Section of RCA Victor. The leak locator, type *EMV-7*, is capable of detecting leaks as small as 1×10^{-5} liter-micron of hydrogen per second. The complete instrument consists of a high-stability d-c amplifier, microammeter, self-contained power supply, and all-metal exhaust system and cold trap, and it operates from a 105 to 125-volt 60-cycle a-c line. The RCA Victor Division of the Radio Corporation of America, Camden, N. J., will furnish any further details.

Down-Coiler Motor. A heavy-duty, mill-type, flange-mounted down-coiler motor, designed to operate under some of the most severe conditions in steel mill practice, has been announced by the Westinghouse Electric Corporation. The new motor is equipped with a heavily reinforced flange mounting; heavy-duty, double-row ball bearings; and heavy cast brass mill-type brushholders. It is of totally enclosed construction, with leads brought out through packing glands and protected by heavy hose. Armature construction uses slot wedges of class *B* material instead of bands, and windings with class *B* insulation for protection against hot spots resulting from high peak currents. The armature also has low inertia for rapid acceleration and deceleration. For further information, write Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

Drum Switch. A new drum switch—Bulletin *350* style *A*—suitable for a wide variety of mounting arrangements for small workshops and industrial services has been developed by the Allen-Bradley Company, Milwaukee, Wis. The switch is the equivalent of a 3-pole double throw switch, and designed for machines and equipment requiring an economical across-the-line starting and reversing switch for a-c and d-c motors rated at 2 horsepower or less. The eight fixed contacts of the switch are cadmium silver alloy, eliminating maintenance. Additional details may be obtained from the Allen-Bradley Company.

Metallizing Guns. Two new metallizing guns, expected to reduce many machine, part repair and salvage costs, and to give 25–30 year corrosion protection to equipment and structures, have been developed by the Metallizing Engineering Company, Inc. The guns, the Metco type *4E* for machine element work and the type *5E* for corrosion protection coatings, have one of the highest spraying speeds yet available in guns designed for hand-held operation. They incorporate a jet siphon principle in the gas head which automatically compensates for variations in gas pressure as high as 10 pounds, and provides a steady, unvarying flame which produces uniform coatings. The *4E* gun is designed to spray all wires from 20 gauge to 1/8 inch in any metal at speeds 40 per cent faster than previous models.

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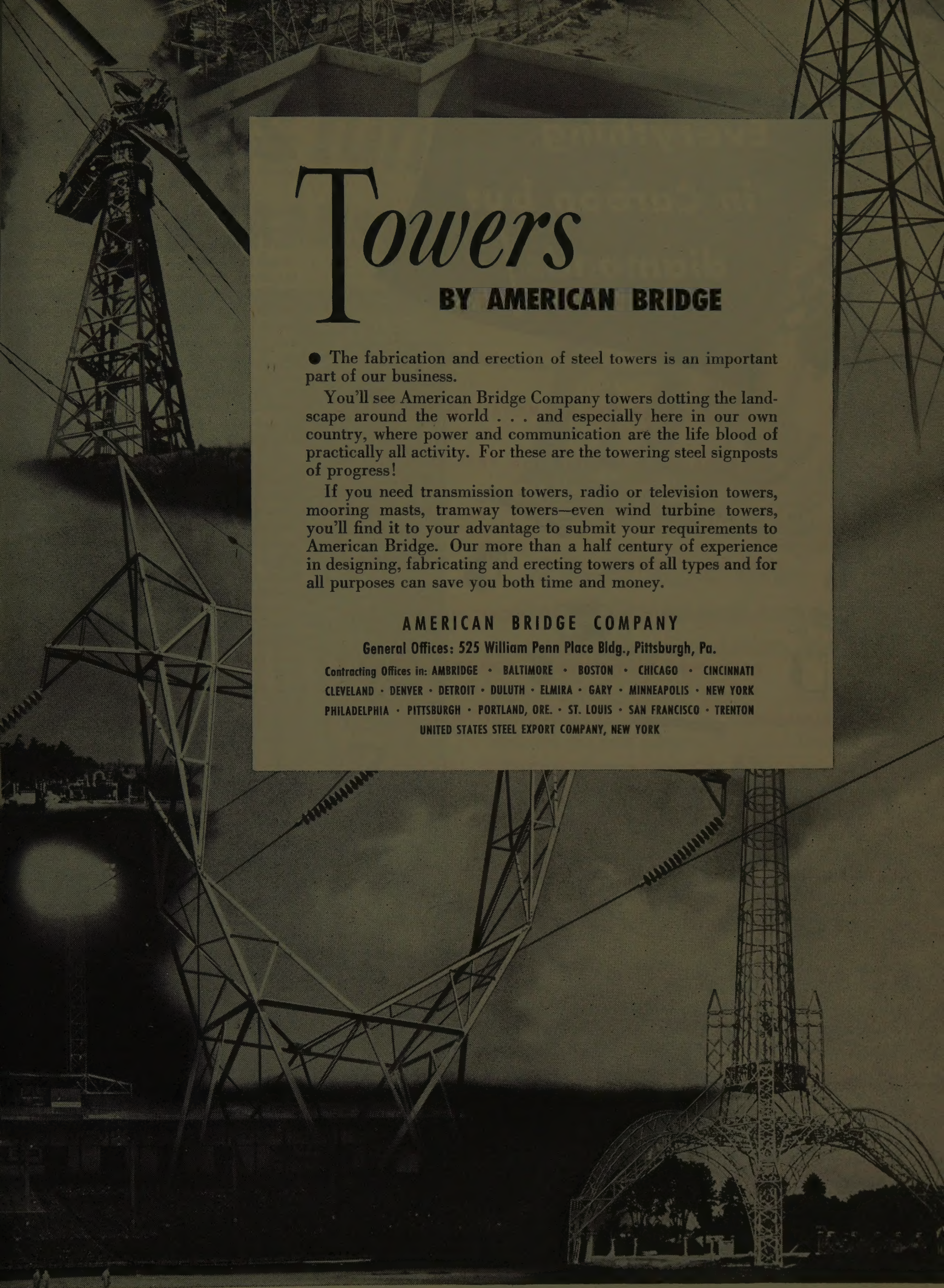

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the *5E* is specifically designed for high-speed spraying of the softer metals, such as zinc and aluminum, and will deposit as much as 55 pounds of zinc per hour, or 15 pounds of aluminum per hour. For further information, contact Metallizing Engineering Company, Inc., 38–14 30th Street, Long Island City 1, N. Y.

Water Stripper. Said to reduce water content of turbine oil to less than one-tenth of one per cent, the Houdaille water stripper provides a practical method of breaking emulsions to permit thorough dehydration of the oil. Use of the stripper eliminates the necessity for changing or discarding turbine oil regardless of the type of contamination encountered, as the stripper removes solid contamination, acids, and other sludge-forming products of oxidation as well as water. It is available for all types of turbines. The Honan-Crane Corporation, Lebanon, Ind., will furnish more complete information.

Vest-Pocket Oscillograph. Up to nine sources of data representing vibration, pressure, velocity, strain, or other phenomena, either static or dynamic, can record simultaneously on a new recording oscillograph, type *5-118*, developed by the Consolidated Engineering Corporation of Pasadena, Calif. Operating from a 28-volt d-c power source, this midget instrument produces dynamic test records $3^1/_2$ inches wide and up to 40 feet long on which the nine separate phenomena can be measured with respect to time and one another. All requests for further information will be supplied by the Consolidated Engineering Corporation, 300 North Sierra Madre Villa, Pasadena 8, Calif.

Radiohm Control. The Centralab Division, Globe-Union, Inc., 900 East Keefe Avenue, Milwaukee 1, Wis., has announced production of a high torque model *I* radiohm control, designed specifically for maintenance of circuit balance under conditions of vibration. The radiohm has a torque range from 2 to 4 ounce-inches. It is available with screwdriver slot on either end or with conventional knob adjustment. Further details will be found in bulletin *42-158*, available upon request to the company.

TRADE LITERATURE

Vacuum Impregnation. The F. J. Stokes Machine Company has published a 32-page brochure on the subject of vacuum impregnation in which the process is explained, applications are given, and the equipment used in the process is described. The brochure may be obtained by writing to the company at 5500 Tabor Road, Philadelphia 20, Pa.

Fusion Welding. A 44-page booklet (*T-2*) on the fusion welding of nickel and the high nickel alloys has been announced as available from the Technical Service Section, The International Nickel Company, 67 Wall Street, New York 5, N. Y.

(*Continued on page 68A*)

Cables run COOLER...
in TRANSITE DUCTS

... reducing copper losses
... increasing current capacity
... prolonging insulation life

YOU REDUCE copper losses ... increase current carrying capacity ... and prolong insulation life, when you run your cables in Transite* Ducts.

Current carrying capacities can be increased in a typical duct bank as much as 5%, or I^2R losses can be reduced 11%, for cables located in Transite as compared with other ducts used for power circuits.

And, Transite Ducts assure permanent duct banks because Transite is incombustible; is immune to rust and rot; is unaffected by electrolysis; will not slag under action of an arc, and will retain its high original strength.

An unusually smooth bore assures no injury to cable sheath, either in natural movement under load, or when pulling-in cables. Long, lightweight lengths can be quickly and economically installed. In addition, a full line of fittings simplifies even the most complicated of installations.

For full information on Transite Ducts, write for Data Book DS-410. Johns-Manville, Box 290, New York 16, N. Y.

*Reg. U. S. Pat. Off.

How Transite Ducts increase current carrying capacities

Type cable 3 cdr. 500 MCM Compack Sector, 15 KV
(6th Edition AEIC Spec.)
No. of cables—3 (all loaded in one bank)
Daily Load Factor—75%
Earth Temp. ambient—20 C

	Transite	Other
Total Therm. Res. to Dielectric Loss (C watts/ft.)	5.66	6.17
Total Therm. Res. to Copper Loss (C watts/ft.)	4.44	4.95
Temp. Rise from Dielectric loss (C)	1.9	2.1
Allowable Rise for Copper loss (C)	59.1	58.9
Allowable Watts per ft. cable	4.44	3.96
Allowable Current—(Amps. per cdr.)	386.	365.
Allowable Current—(Relative %)	105.6	100.

Johns-Manville *Transite Ducts*

TRANSITE KORDUCT— for installation in concrete

TRANSITE CONDUIT— for exposed work and installation underground without a concrete encasement

(Continued from page 64A)

Selected Motion Pictures. A 60-page catalogue of 16-millimeter sound films and filmstrips, "Selected Motion Pictures," is available to industrial plants, stores, and offices. The catalogue describes more than 1,400 different educational, recreational, and training films, many of which are available for plant showings at no charge except transportation. Association Films, Inc., 347 Madison Avenue, New York 17, N. Y., will supply copies upon request.

Radio Catalogue. The Allied Radio Corporation of 833 West Jackson Boulevard, Chicago, Ill., has published its new 1952 212-page catalogue, number *127*, which covers everything in radio, television, and industrial electronics. The catalogue is available upon request to the Allied Radio Corporation.

Controlog. The Clark Controller Company has released an 80-page bulletin, "Controlog, A Digest of Motor Controls," which may be obtained from Mr. E. C. Roberts, Advertising Manager, The Clark Controller Company, 1146 East 152nd Street, Cleveland 10, Ohio.

Speed Reducers and Gearmotors. A 96-page pocket-size catalogue describing Abart speed reducers and right-angle gear motors has been announced as available from the Abart Gear and Machine Company, 4834 West 16th Street, Chicago 50, Ill.

Electronic Tubes. A new booklet devoted to industrial electronic and special purpose tubes has been published by the Milo Radio and Electronics Corporation, 200 Greenwich Street, New York 7, N. Y. It may be obtained upon request to the company.

Mica. Descriptions, specifications, and applications of built-up mica electrical insulation products are covered in a bulletin released by the Publications Department, Insulation Manufacturers Corporation, 565 West Washington Boulevard, Chicago 6, Ill. The bulletin, number *527A*, is available upon request.

Protective Lighting. Complete plans for outdoor industrial lighting are provided in a new 24-page booklet, "Light for Plant Safety and Security," number *B-4791*, available from the Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa., upon written request.

Switches and Circuit Breakers. The Pacific Electric Manufacturing Corporation, 5815 Third Street, San Francisco, 24, Calif., has published four new catalogues: numbers *130*, *159*, *164*, and *585*, which describe their outdoor group-operated side-break air switches, grounding switches, manual operating mechanisms for tilting-insulator air switches, and reclosing oil circuit breakers, respectively. The catalogues all may be obtained upon request to the company.